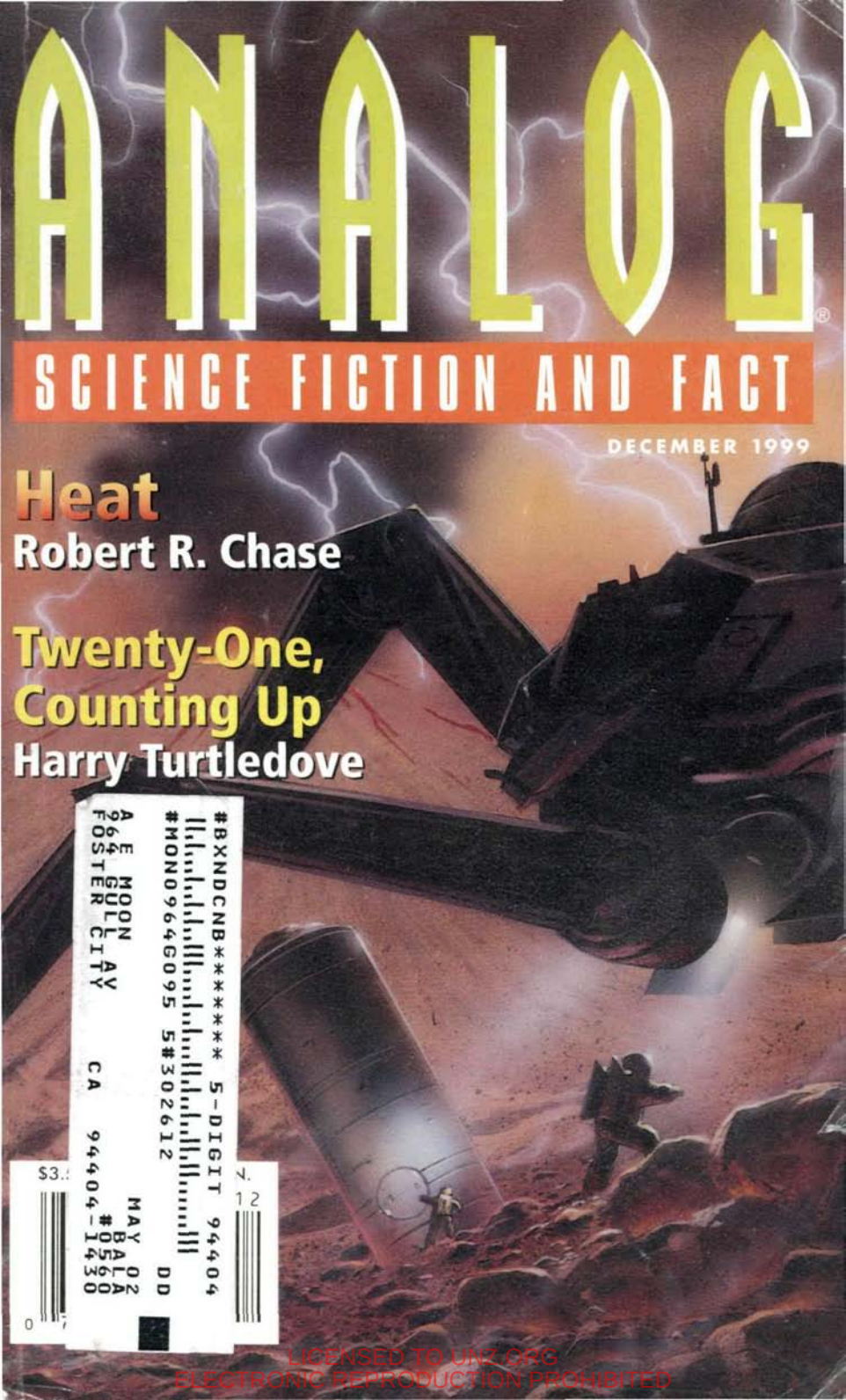

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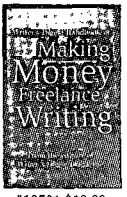

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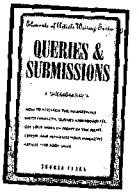

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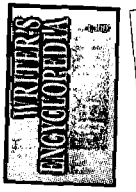

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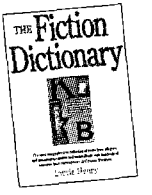

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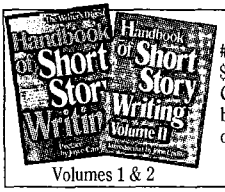

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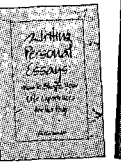

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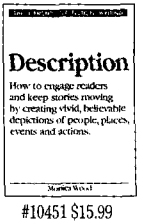
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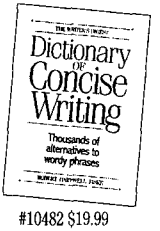

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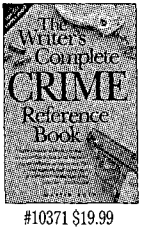

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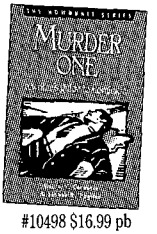

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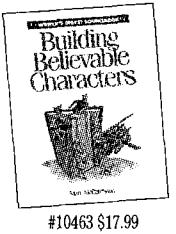

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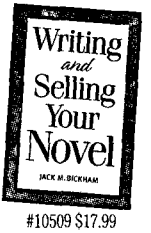

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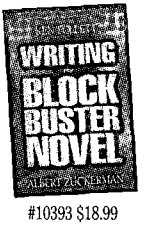

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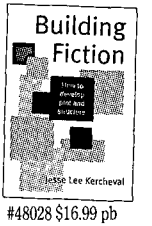

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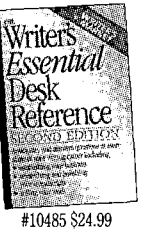

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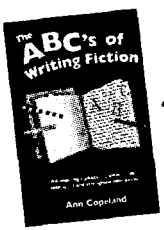

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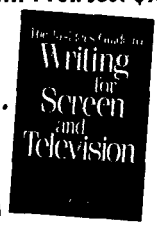

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ANALOG

SCIENCE FICTION AND FACT

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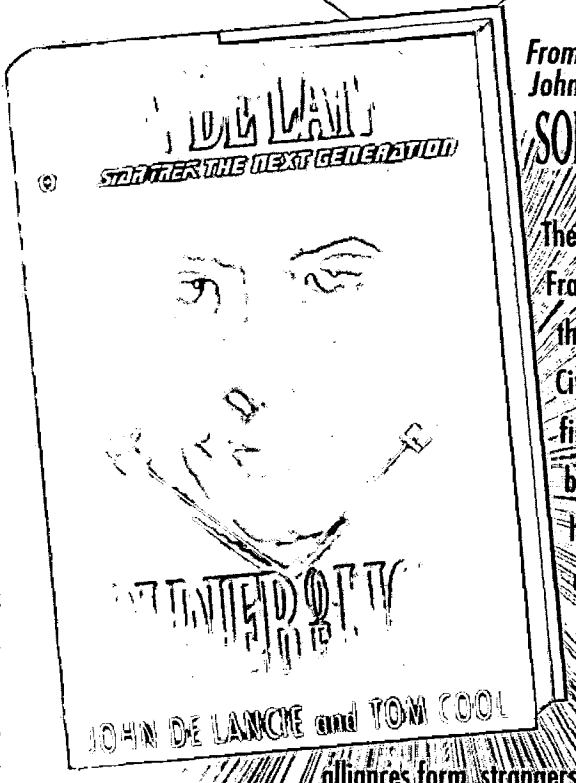

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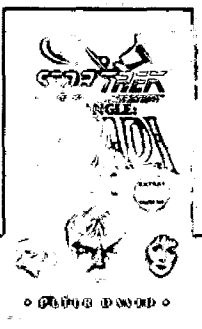

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EDITORIAL Stanley Schmidt

HARDLY EVER SAY NEVER

There are some lessons that people seem unable to learn, no matter how often they're explained and vividly demonstrated. One of these is the folly of assuming that this or that will never be done because it can't be done—or is too difficult or expensive to do—*now*.

The stumbling block seems to be the widespread inability to distinguish between *now* and *forever*. Or, to put it another way, the widespread belief at the gut level that wherever we happen to be at the moment, in the development of any characteristic of the world in general or our own civilization in particular, is the pinnacle of evolution, a zenith beyond which we cannot realistically expect to progress. Oh, nobody *says* they believe that, and most people, if accused of such a naïve belief, would vehemently deny it. But their actions usually say otherwise. Despite the long record of unceasing change throughout human history, despite the fact that everybody knows things are very different now from what they were a hundred or even ten years ago, despite the fact that we all know that computer systems are commonly considered "obsolete" in three or four years and thousands of individuals and companies are actively competing to change things even faster—despite all that, an astounding number of us persist in acting as if we believe the current state of the art defines The Ultimate Limits.

One of the more interesting recent examples of this phenomenon directly involves acting in another sense. A Gannett newspaper feature article, headlined "Computer 'Actors' Imitate Humans on the Big Screen," dealt with the possibility of computer-animated "characters" becoming realistic enough to pass as human, not in obviously animated cartoons, but in movies intended to be as realistic as any movies ever made. What I found most interesting about the article was not, of course, the shocking novelty of that concept (it didn't have any), but the shocking (though no longer surprising) naïveté of the people who found it absurd and not worthy of serious consideration.

It is worth noting that one group *not* shrugging the suggestion off was the Screen Actors Guild. "Despite assurances that no digital human could replace a Robin Williams, Will Smith or Gwyneth Paltrow," the article reported, "SAG spokesman Rafe Greenlee says computer-generated actors 'are definitely something we're very interested and concerned about.'"

As well they might be. It's true that nobody *now* can computer-simulate humans well enough to pass as real in a sustained close-up. But that is not an intrinsic limitation of computer simulations.

The idea, like many others, is by no means new to science fiction readers. But reality has been catching up with it rapidly, and it didn't come screeching to a halt when it reached the present. It has plenty of forward momentum, and will continue to advance—likely faster than anybody anticipates.

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Grey Rollins' story "The Ghost in the Machine," for example, appeared in our March 1993 issue. The ink was hardly dry on our pages when Steven Spielberg's *Jurassic Park* hit movie screens all over the country with its astoundingly lifelike dinosaurs. Admittedly Rollins' story took things a good deal beyond even present state of the art, with its computer-generated actors—or "synthespians," as visual effects workers in today's movies already call them—who not only *looked* real, but had enough artificial intelligence to ad-lib variations on the script. But that's just a matter of degree. Even that may eventually come to pass. Meanwhile, many people associated with the industry are still casually shrugging off the possibility of even a single animated human sufficiently detailed to pass for real in a theater—even as more and more synthespians take over small and nonhuman roles.

Some of the best-known recent examples are the crowd scenes in *Titanic*, populated by swarms of fictitious folk; the oversized gorilla in *Mighty Joe Young*, who was shown in unprecedented close-ups; and several alien characters in *Star Wars Episode 1: The Phantom Menace*. None of those achievements is quite on a par with showing comparable close-ups of humans, not because humans are all that special in the cosmic scheme, but simply because we are extraordinarily familiar with ourselves. A lot of our built-in processing power is dedicated to recognizing very fine details of things like skin texture and facial expression in our own kind. Convincing human close-ups will require handling those details with an accuracy and precision not needed when people are seen only briefly and at a distance, or when the close-up subject is of a species we don't know so intimately.

But that, too, is just a matter of degree.

When the director of *Mighty Joe Young* said he would never consider using a synthespian in a starring human role for the whole length of a feature film, he was likely showing good judgment. It's quite possible, though by no means certain, that the technology will not be good enough during his career. But, if people keep working on it, it almost certainly will be at *some* time. (My current guess is ten years.) At least some of his artistic heirs *will*, I say quite confidently, create and use synthetic stars.

Synthetic extras and stuntmen are already commonplace, and somewhat more prominent roles are starting to appear. The number of artists creating computer-generated characters at Industrial Light & Magic (ILM) has increased a hundredfold in ten years. With that much creative energy going into the quest, the question about digital stars is not whether they will happen, but simply *when*.

It's true, as the Gannett article claimed, that, "For now . . . it still costs too much to create a digital star." But

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the key phrase there is "for now." One person quoted in the article said, "You can hire one person to act, or you could hire a crew of twenty to fifty to create this one performance." That's probably a fair description of present-day economics; but it by no means follows, as he says in the next sentence, that "It's *always* [emphasis mine] going to be cheaper to hire one person to do it right then and there."

That kind of extrapolation ignores a multitude of historical examples of what has happened in the past evolution of technologies, in terms of both capability and cost. Consider electronic calculators. The first one I saw created quite a stir in the physics department where it appeared in 1965. It filled a typewriter table (remember typewriters?), weighed maybe fifty pounds, cost $3,000, and did addition, subtraction, multiplication, division, and square roots. In 1982 I gave my wife, as an afterthought to a birthday present, a calculator with almost exactly the same capabilities, but only slightly larger than a credit card and costing $10. A few years after that, a camera store I frequented was throwing an even smaller one in with my change, just as a token of appreciation for my shopping there, every time I went into the store.

Or consider the calculator's more sophisticated sibling, the computer. Not many years ago, a single computer typically filled a large room and cost so much that relatively few institutions and hardly any individuals owned one. Now nearly half the households in the U.S. own at least one, and some have several. Virtually all of those are both far smaller and far more powerful than those monsters of two or three decades ago; many of them fit comfortably inside a briefcase and have elaborate multi-tasking and multimedia capabilities.

And they're getting more so all the time, at a rate which is still increasing.

So if it takes a crew of twenty to fifty people to simulate one featured performance now, in a few years the same job may just need a few—or one!—with a good bank of hardware and software. That software will quite likely include subroutines for automating what are now long, complicated animation procedures. Each of the hundreds of human facial expressions, for example, might be applied to a particular face, and modified for subtle nuance, with a few mouse strokes.

Or, eventually, even less.

So the SAG representative who is concerned about overzealous animators

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stealing the identities of real actors, but shrugs off the suggestion that synthespians could ultimately *replace* human actors, may not be looking far enough ahead. "Somehow," Gannett quotes him as saying, "there's got to be an artistic genius somewhere, whether in an animator's mind or Jim Carrey's. To think they'd replace [actors] completely is unrealistic."

Well, maybe. Or is it more unrealistic to assume that they couldn't?

It's pretty clear that, with only easily foreseeable advances beyond the present state of the art, animations even of featured humans seen close up *can* be made realistic enough to compete in front of audiences with live actors. It's just as clear that the means of doing so can be streamlined enough to make it economically competitive. At that point, human actors will have some real competition to worry about. Mr. Greenlee is quite right that at some point some artistic genius will be required—but he glosses too comfortably over his own acknowledgment that that genius could reside in an animator, or even a programmer, rather than an actor.

And, ironically, superstars may be the most vulnerable when that happens. The biggest stars are currently paid so much more than programmers that animating a substitute would have to require an awful lot of programmers to make them more expensive than the star. The number of programmers required to get a given result will continue to decline. . . .

And when the programs get sophisticated enough, they can be used to generate lots more performances for a very small fraction of the cost of paying a human superstar for equivalent performances. Sure, much more will be demanded of stars than of extras, whether they are human or digital. But wherever you put the bar, if you're determined enough, you can probably get the machine over it. And audiences will care mostly about the results. Initially, as in the first part of Mr. Rollins' story (when his producer used a synthespian to replace just one recalcitrant actor), digital stars may attract viewers solely by their novelty. But if their performances are good enough, audiences will by and large cease to care which performers are real and which simulated. They'll support the performances they like, at the expense of those they don't, regardless of their origins.

At which point the economics will do some very dramatic (no pun intended, he lied) rearranging. I can easily imagine, for instance, scenarios in which human stars still exist, but can no longer command the huge fees they once did. In fact, those superstar fees might increasingly go instead to those who create the best simulations. . . .

Some of whom, eventually, might even produce Grey Rollins' 'intelligent' simulations.

All this is just another living example of the dangers of assuming that the forces of change that brought us to the present will somehow let up in the immediate future and beyond. The SAG is to be commended for taking digital competition at all seriously, this early in the game—but the chances are good that they're still not taking it seriously enough. Not everything that can happen does, but a lot of these things do. And quite often, if they happen at all, they happen a lot sooner than most folks—even SF writers!—would expect.■

We must all hang together, or assuredly we shall all hang separately.

— Benjamin Franklin

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Robert R. Chase

HEAT

Human actions can be judged by their motivation or their consequences—which are disturbingly close to independent variables.

Illustration by Ron Miller

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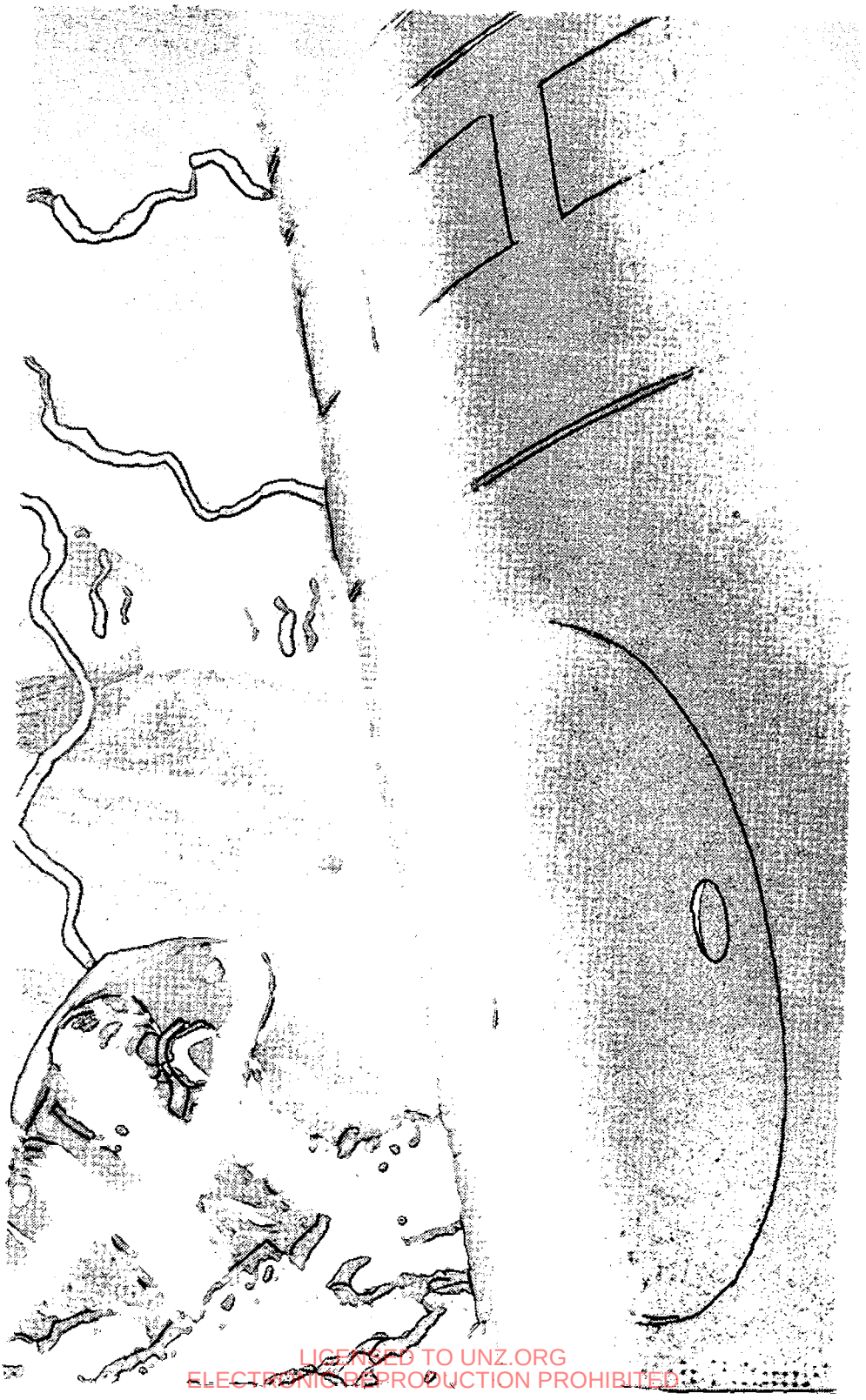

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Sweat soaked my hair and ran down into my eyes. I tried to shake it away, afraid to remove my hands from the control panel, angry with my body for responding to pressure which was purely psychological. The interior thermometer had settled on twenty degrees Centigrade less than five minutes after I sealed the hatch of the *Pellucidar Express*. It had clung tenaciously to that reading ever since.

Still, I would rather admit that I was suffering from nerves than have to deal with the implications of a non-functioning thermometer.

The exterior reading had been almost as constant for almost as long, but the figure it displayed was 1,160 degrees Centigrade. Glancing around at the mostly plastic control panel, the cheap carpeting glued to the floor, at my own shiny hands, I tried not to think of how many of life's mainstays char and melt at that temperature.

Two of the displays showed a slow, steady movement. According to one, I was four hundred meters below the bubbling surface of a lava lake which had only recently appeared on the side of Mauna Loa. The other told me that the hull was being subjected to nearly one hundred atmospheres of pressure.

To get the right sort of advertising these days, the small businessman has to go through hell. Sometimes, it seems, literally.

With an effort, I wrenched my attention back to the mission. Along with my primary purpose—generating profitable publicity for Maxwell Associates—I had an ostensible purpose which required my efforts. I was supposed to be conducting research, exploring the last frontier on, or more accurately in, the Earth. Selling Vreality rights to *National Geographic* had helped pay for the construction of the *Pellucidar Express*. The company would receive twice that amount on successful completion of the mission. Successful completion was defined in terms of my survival, and the return of the data recordings to the surface.

One part of my mind was already composing the narration: "The Earth continually gives birth to itself in volcanoes like those of the Hawaiian island chain. The mission this day of David Maxwell and the *Pellucidar Express* is to perform an ultrasound examination. But this examination must be performed from inside the patient!"

And from that opener, straight into the first set of commercials. I would have to be careful of extended metaphor, however. Things could get sticky if I pushed it too far.

The truth of the matter was that what I was experiencing was too awesome ever to be captured by Vreality or any other medium. The only way even I could understand the experience was through the software Sandy had written for the Doppler sonar. Setting the knobs so that the high definition flatscreen displayed a horizontal view, I saw a brown wall at the limits of resolution. This was the wall of the magma chamber. In front of it, red and blue vapors swirled about like the doomed lovers in the second circle of Dante's Hell. Confused about what was right and wrong, tossed to and fro by their uncontrollable passions. If I were to survive, I would have to know the right thing to do and be able to hold to it.

Most of the blue was concentrated in the central plume rising from the depths. With the volcano in a steady state, as it presently was, this upwelling was almost exactly balanced by the cooling magma, coded red on my screen, which was sinking around the perimeter of the funnel.

Two caveats, as my lawyer Izzy, would say. The first was that Mauna Loa is not always in a steady state. The relatively gentle convection currents on which I was navigating could be overcome by sudden surges of magma. These might endanger the recovery crew on the sur-

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face, on whom I was almost totally dependent. They might also dash my craft against the sides of the funnel. The Daimonium sheath was not constructed to withstand that sort of impact. One crack might not allow in enough heat to melt the hull. It wouldn't need to. The heat conducted into my cabin would, in short order, turn me into something that would look like it had been left in the deep fat fryer too long.

The second caveat was that these surges were unpredictable. After all, had it been otherwise, there would have been no excuse for my presence or my research.

A groan vibrated through the hull, the sound a strong man, severely wounded, might make through clenched teeth. I looked at the pressure gauge. It had just passed one hundred atmospheres. I decided I had proved enough. If this couldn't garner sufficient publicity for Maxwell Associates, then the hell with it.

I pressed the send button. "This is the *Pellucidar Express*. I'm going to dump ballast and begin my ascent."

"Damn about time." The earphones reproduced Sandy's relief perfectly. She had been extremely troubled when I had decided on this "suicidal stunt." Only imminent bankruptcy had forced her reluctant consent.

"Hustle on up, hon. I've got a backer wants to meet you."

That was good news! The publicity was paying off already. I hit the ballast release. There was a jar as the arms holding the tree-trunk-thick iron bars swung wide and their burden dropped away. I felt myself relax. Theoretically, the cable was strong enough to lift me to the surface even with the ballast still attached. I was relieved I would not be testing that prediction.

I adjusted the diving planes to guide us into the central plume. Ever so slowly, the *Pellucidar Express* began to rise.

With a lurch and a roll, the craft broke the surface. The cabin righted itself abruptly as the cable pulled taut. The cabin floor seemed to spring upward as the lava released its hold. I fought vertigo as I felt myself falling sideways. Swinging in ever-decreasing arcs, the craft was lowered gently to the lava field I had left six hours previously.

I made a last check of all exterior readings, popped out the data disk and flicked off all the power except the lights and the phone headset. For the moment, there was nothing for me to do but wait for Moe and the recovery crew to break the Daimonium sheath sealing me into the *Pellucidar Express*.

A series of sharp raps on the hull, followed by a tearing sound. "Okay, Dave, you should be able to exit." I was spinning the wheel on the hatch even before Sandy finished speaking. Little gusts of cold and hot air chased themselves through the cabin as the hatch slid aside. Hot air from the lava pool only a few meters away; cold air from being nearly four thousand meters above sea level. Moe's smiling face looked in and nodded approvingly.

"So, you are not crispy critters after all," he said, in a mellifluous accent. "The boys will be sorry to have lost money on you."

I laughed as he helped me out of the hatch and down the portable stairway to the lava field. Behind the lines there were a gratifying number of media reporters, gyrocams perched on their shoulders. Three figures were walking toward me. Two I recognized. Sandy, of course. Next to her, Regina Hallaj, CEO of House of Hawks. Maxwell Associates used her services as often as we could afford. Which wasn't all that often.

In front of both of them strode a man who was probably my height, though he somehow conveyed the impression of being taller. Khaki-colored longcoat and trousers had been cut so as to suggest a uniform. His skin was the color of mahogany. Hawk eyes devoured the *Pellucidar Express*.

"Chandra Shivaji, may I present to you

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Mr. David Maxwell of Maxwell Associates. He has just demonstrated, I believe, that he has the abilities your require. David, this is Greater India's Minister of Advanced Technology." With a proprietorial smile, Regina held out her hand in my direction.

Shivaji seemed not to notice her. "This vessel, it has survived ninety atmospheres pressure."

It took me a moment to realize that he expected me to answer. "It has survived one hundred atmospheres pressure."

"And a temperature of five hundred degrees Centigrade?"

"More than twice that."

"And you can prove this."

"It's all here," I said, holding up the data disk. "Subject to verification by both National Geographic and Smithsonian research teams."

For the first time, Shivaji allowed himself a thin smile. "Good. If you can provide materials to my specifications, you will be well compensated. Let us proceed to you trailer where we may discuss terms."

"Your Excellency, I think—" Regina began.

"Your task is finished, Ms. Hallaj. Ratnatunga will see to your payment."

Hot and cold winds buffeted me with renewed force during the walk back to the operations trailer. Sandy and I exchanged glances, as disturbed by Shivaji's tone as by what he said. It could be that he was unaware of Regina's doctorate; she wore her learning lightly. Yet the edge in his voice made me think that he was consciously denying her title.

I stopped at the door to our trailer to wave at the media while Shivaji waited impatiently. Then we stepped inside.

Regina was still with us. Shivaji's eyes flared as soon as he realized it. Regina turned from him and addressed Sandy and myself.

"Would you care for my services in the negotiations?" she asked.

"You can't work for them," Shivaji objected.

"I could not work for them while under your employ," she replied. "That is no longer the case."

"I am not sure we can afford to retain the services of the House of Hawks CEO," Sandy said. "At the moment, we are a bit, ah, overextended."

"This is a conflict of interest," Shivaji said. "You have no right to disclose our confidential information."

"I will work on contingency," Regina said. "You will pay me whatever you find my services to have been worth." To Shivaji: "No confidential information was provided to me, so there is nothing for me to disclose."

"This is unacceptable." Shivaji turned to me. "Unless you dismiss this woman, you will have nothing to pay her or yourself."

Sandy winced. She tried to take care of the financial side of the business so I could concentrate on the engineering, but I knew without being told that we could not afford to turn down government investors.

Apparently Regina knew that as well. She grimaced and shook her head. "That will be unnecessary. I withdraw—"

"No."

"What?" Shivaji looked at me with a combination of astonishment and fury. Looked at me, even though Regina had been about to concede, even though Sandy seemed ready, however reluctantly, to support him.

Because they were women, and therefore distractions unworthy of notice. In my grandmother's time, it had been assumed that this combination of male chauvinism and misogyny was a cultural overlay on a underlying animal innocence. In fact, it grows as naturally as cancer in some men, who sometimes manage to impress it on the society surrounding them. I have seen it in Ivy League graduates and in Mexican day laborers. Shivaji probably disliked Regina simply because she was both intelligent and necessary to him.

"I mean that Maxwell Associates have

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accepted Dr. Hallaj's offer—" I watched Shivaji's eyes widen at my insistence on her title, "—to aid in our negotiations. The House of Hawks is, if not the largest, certainly the most respected Librarian/Generalist organization in existence. Its aid has been invaluable to us in the past. You must have formed the same high opinion to have retained them yourself."

Shivaji sat back in his chair and regarded me wordlessly for perhaps thirty seconds. "You realize," he said at length, "that I do not have to deal with you. It is a matter of convenience. If necessary, my technicians can reverse engineer your Daimonium process. Stubbornness can cost you a great deal."

"If you so much as touch the *Pellucidar Express*, I will have the data cops on you so fast your head will spin," Sandy said.

I waved her to silence. "Excellency," I began, "as the Minister for—was it Advanced Technology?—you are no doubt aware that the most advanced materials processes involve a certain amount of 'magic.' That is, you might contract with me to deliver the Daimonium process to you. And I might attempt in all good faith to do so. I could give you the recipe for the material, the construction diagrams of the nanites, and the algorithms for the controlling software. And what you have might be totally worthless because I would not be able to tell you some crucial fact or process that I don't know, and don't even know I don't know. Something unique about the isotope ratios of our raw materials. Perhaps the factory foreman in charge extruding the composite had adjusted the heat treatment or the extrusion speed in a manner so slight that he hardly notices himself what he has done. Or it might be the controlling AI. Such programs are always modifying themselves, adjusting to their surrounding and adjusting their surroundings to them. Sometimes they cease working for no immediately discernible reason.

"Or everything might work together at first try. It is possible."

We were both silent for two breaths. "It is stupid to argue over this!" Shivaji said. "Hallaj can stay if you wish. You are only cutting into your own profit. Her presence will not obtain for you a single rupee more."

I nodded agreement.

His thumbprint activated his notebook. "Here are the configurations which require your treatment. Interior temperatures are to be maintained at twenty degrees Centigrade, plus or minus fifteen degrees. Exterior temperatures may exceed five hundred degrees. Exterior pressures will reach ninety atmospheres."

I studied the diagrams with growing curiosity. The largest "configuration" appeared to be a tower almost ten floors high. The second I recognized as an Arachnid All Terrain Personnel Carrier. The third appeared to be a pressure suit.

"This will cause us the greatest difficulty," I said, pointing to the pressure suit. "Daimonium is not flexible. The joints are going to be a real problem."

From his previous behavior, I expected an explosion from Shivaji. Instead, he nodded seriously.

"Are there other environmental factors which may affect the performance of the Daimonium?" Regina asked.

Shivaji frowned. "Such as what?"

"Radiation. Ultraviolet exposure perhaps?"

Shivaji's finger indicated the tower. "This . . . structure will be exposed to both ultraviolet and hard radiation for periods on the order of a week."

Sandy's face mirrored my alarm. "What intensity?" I asked.

"I do not have the exact figures. Perhaps a thousand rads during mission life. This can be provided to you." Shivaji shook his head, as if trying to dodge a troublesome insect. "None of this matters. Technology has been sufficient to handle these exposures for more than a century."

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"It matters a great deal," I said. "The Daimonium sheath may degrade if not protected from the radiation. On the other hand, the radiation shielding may decay if not protected from the heat."

"I think you need to tell us everything about how and where these structures will be used," Sandy said.

"These are state security matters," Shivaji objected. "You have a job. It does not clear you to know all our secrets."

"I don't want to know all of them. Only those relevant to the task. The matter of radiation itself might have been enough by itself to ensure failure, if we had not learned about it. What else is there?"

He stared at me silently.

I sighed, aching at the thought of all the hard currency, which might save my company from bankruptcy, about to fly away. "Unless I know everything about the environment in which these structures will be used, I must decline the commission. The dangers in case of failure are just too great."

"For example," Regina said, "you might like to talk about any pH extremes to which the sheathing will be subjected."

Shivaji's glare was deadly. "You know." It was an accusation.

I had come to the same conclusion. Regina was not interested in any fee we might pay her. She had been stonewalled by Shivaji and had not liked it.

"I have made intelligent guesses," she said. "After all, I started as a Librarian. Knowledge is our business."

"What is the answer to the question?" Sandy asked.

Shivaji stared at her for an instant, then seemed to collapse into himself. "It will be exposed to sulphuric acid in aerosol form twice, probably for no more than ten minutes each time."

I blinked, trying to imagine what sort of hellish environment Shivaji proposed to explore.

"I will tell you everything," he continued in a low voice. "In return, you must promise the strictest confidentiality." He thumbed on and held up a standard Geneva Vocorder. Sandy immediately did the same for our records. Then all three of us promised to maintain in confidence all information which would be disclosed to us, subject to the usual exceptions for planned or disclosed illegalities.

"And I assure you," he said, with something of his original fire, "if you break that pledge, actions at law will be the least of your worries."

There being nothing intelligent to say to that, we said nothing.

"Six weeks ago, the Air Force of Greater India, under the direction of my ministry, tested a drone spacecraft equipped with what we have called a Maya Drive. We started the test from thirty degrees behind Earth orbit, to be free, we hoped, from unwanted observers. Our target was Venus. Cramers established the correct vector and accelerated it until it attained the orbital speed of Venus. Then the Maya Drive was activated. It vanished. At that same moment, our observers in orbit about Venus picked up its appearance."

"A faster-than-light drive?" I asked. "How fast . . . ?"

"That is a meaningless question. There is no speed, because there is no distance. Extension is a delusion. Space is a delusion. The Maya Drive annihilates this delusion for a quantum instant, and allows a vessel to appear at any arbitrary distance from its original location."

His voice dripped disdain, yet there was another emotion I was not able to name.

"But you lost it," Regina said, almost inaudibly.

"It appeared exactly where we had programmed it to appear." If Shivaji had heard Regina, he gave no sign. "It emerged five hundred kilometers above the cloud deck. It was supposed to make the corrections to take up orbit at that altitude. Something went wrong. The drone continued without deceleration straight into the atmosphere. There was no way any of the waiting craft

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could intercept it, much less alter its course. We watched, horrified, as it turned into a meteor.

"Fortunately, buried in all its programming, was an automatic landing sequence. This activated itself and slowed the craft to what appears to have been a safe landing. The drone is there now, in heat which melts lead, beneath clouds which rain acid. It may have been altered by stresses from the Maya Drive. Perhaps that was the cause of the failure to achieve orbit. Perhaps those same stresses are fatal to humans. The only way to find out is to retrieve the data disks on the drone.

"That is your task, Mr. Maxwell. To descend into hell and return, if you are able, with the key to the stars."

2

I expected Shivaji to hand me detailed specs and demand thirty-six-hour work days until the project was finished. I did not expect that nothing would happen until after a formal presentation to the Council of Ministers.

"Stop complaining," Sandy said, as she adjusted my ascot. Since I had neither a Registered Name nor a Company Crest, the pattern was simply one of the basic ungendered designs appropriate for United States citizens. "I know you hate parties, but for what we are being paid, you can put up with more than a few hours of boredom. And you may even enjoy yourself, if you unbend a bit."

"Unlikely," I replied. "Most of these things are attended by self-important zombies as beautiful as peacocks and with brains to match—"

"That's unfair!"

"—but the really frustrating thing is when you meet someone interesting, you can never talk because the music is so loud that the floor is shaking."

She stepped back and regarded me. "Not too bad, really. Just try not to look so martyred."

Our cab took us from the hotel through the electronic checkpoints into the New City Government Center. We sped through brightly lit, oddly empty streets. New City had not been designed for pedestrians. There were stories of a man who had wandered away from a broken-down car and nearly starved to death in the deserted streets, unable to find an entry into any of the silent, brilliantly lit office buildings.

At Gandhi Hall, the doors slid open and we were taken up to the main ballroom, where Shivaji presented us to those members of the Indian government most important to his project. A blur of members of the Council of States. A sharp-eyed prime minister. Colonel Rucha Sattayarak of the India Space Force, who hoped to be the first man to exceed lightspeed.

Earlier that afternoon, I had made the basic Maxwell presentation to many of these same dignitaries by remote. An animated demon—Maxwell—stood guard at what looked like an open doorway. Energetic molecules, drawn to resemble corporate go-getters, were batted back from the door by the demon. Their "cooler" cousins, drawn with dark glasses and berets, were allowed to amble through. Gradually, one side became searingly hot while the other chilled down to Arctic inactivity.

"This violates the laws of thermodynamics," the prime minister observed.

"No more so than life itself violates those laws," I replied, wondering who had fed him that statement. "Or any refrigerator, for that matter. The point is, you have to consider the system as a whole, not just parts of it. The demon doesn't work for free."

The prime minister's smile was disturbingly shark-like. "I think we understand each other, Mr. Maxwell."

This evening, however, was supposed to be a purely social occasion. Yet in all the smiles and murmured compliments I sensed an odd tension, as if we were chess pieces being displayed so that our strength could be properly appreciated. An odd fancy, since I had no idea what

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the actual game might be, or the identity of the opponents.

A small orchestra occupied the far end of the room. Sitars and vinas were plucked, bansris and shahnais skirled, while mridangams and tabla were battered to a rhythm I could not quite catch. "Isn't it wonderful?" a matron taller than myself asked. "These instruments were never designed to be played together. This is truly Pan-Indian music." I agreed that the result was quite astonishing.

Sandy got involved in a discussion on the merits of the sari as female dress and didn't she think the constantly moving patterns which had become fashionable in Europe were inexpressibly vulgar? I retreated to the bar for a rum and Coke and nearly choked on the result. The mixture was nearly pure rum; the Coke apparently serving only as food coloring.

The long walls were lined with ornamental trees surrounded by polished wooden benches. I took a seat on one of these where I would be almost out of sight beneath the overhanging branches, able to nurse my drink quietly. Only then did I notice that the adjoining bench had an occupant, a young man who had been gazing intently at the lighted screen of his notebook. I extended my hand to introduce myself. My companion regarded me with a fixed smile and somewhat alarmed eyes. I wondered if my words were as meaningless to him as they would have been to me in Tamil or Punjabi.

He put that fear to rest at once. "Ah, so you are a practical man," he said, a trifle wistfully. "You invent new processes, you form your own company to market them, and fight off the corporate carnivores who would seek to devour you. It is easy to see why you have been made part of this effort. Many times have I wished for these qualities in myself."

I wondered how Sandy would have responded to the characterization of me as a practical man. If I had been able to resist any "corporate carnivores" it was probably because they had not yet deigned to take notice of my company.

"Surely you are being too modest," I said, reminded of one or two youngsters I had hired over the years who had needed no more than freedom and confidence to make their talents bloom. "From what I have seen, Shivaji hires only those who can pull their own weight. Wouldn't you agree, Mr. . . .?"

His blush was distinctly visible even beneath his dark skin. "Oh, you must forgive my terrible manners, Mr. Maxwell. I am Ramesh Sadanada. I play with numbers." He indicated his notebook screen, which was filled with a notation I had never seen before. "That is the small talent which his excellency Minister Shivaji wishes me to exercise on behalf of our country."

Numbers could be everything from accounting to interplanetary navigation. "How did that come about?"

A self-deprecatory shrug. "Largely because I was such a bad student in everything else. Most literature I found impenetrable. History was a chaotic swirl of arbitrary events. Only in numbers was there order, immediately comprehensible on its surface, yet with greater depths and more basic relationships always beckoning me on. I think it was in desperation that my teacher gave me copies of some old notebooks to work through."

Ramesh fell silent. "And?" I prompted.

He shook his head slowly, as if I were bringing him back from a great distance, but only partway. "It was as if I had been living in a foreign country for years, and then suddenly heard someone speaking my native language, a language I had nearly forgotten. It started with simple things, like a different way to compute pi. From there it went on to a series of number proofs. There were steps skipped, but of course they were skipped: they were too obvious to be worth the time to state explicitly.

"Although . . . once or twice, he made a mistake." Ramesh looked at me as if he were confessing the flaw of a particular-

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ly favored cousin. "I had to go over and over those proofs, because they were the type of mistakes I would make."

"Did you find enough of interest to stay in school?" I asked.

"I found . . . I found the foundations of the world. Those notebooks were not merely a collection of theorems and proofs. They were the outline of a way of understanding reality. There were incomplete proofs, sections which were no more than hints and speculations. All previous mathematicians had avoided these sections because they were so fragmentary and contradictory. I saw them as markers for my own explorations.

"There is so little I have been able to do so far. But that little has been enough to show me that this, all of this, is illusion. Maya. Professor Yamaoka sees it in terms of physics. He says that I have proven what should have been intuitively obvious. That the Universe we see all around us and the state which immediately preceded the Big Bang are equivalent. They have to be. It is the only result which makes sense."

Only then did my brain belatedly turn on. "You invented the Maya Drive."

Again, the shy, embarrassed smile. "I showed that it could be done. Others, good with their hands, people like you, designed the drive machinery. Especially Professor Yamaoka. I wish we were still allowed to talk."

"Why aren't—?"

"He is not Indian." Ramesh's eyes were downcast, his voice flat and without affect. "It was considered an unacceptable security risk for him to be associated with the project."

For the first time, I understood the emotion underlying everything he had said. The loneliness of an exile in an alien land. The loneliness of a genius who saw wonders, but had no one who could understand his discoveries.

"What about the author of the notebooks?" I asked. "You haven't told me about him."

"Srinivasa Ramanujan has been dead for more that a century and a half."

Two months later, a raging argument on the progress with the Daimonium sheathing came to a halt with the news that Ramesh Sadanada was dead. He had been visiting relatives near the border of Nepal, in a land vehicle so old it required the direction of a human driver. Snow dusted the roads. The tires of previous vehicles had melted the snow, which in places immediately refroze as glare ice. The police report also indicated brake failure, probably caused by a combination of age of the vehicle and the fact that Ramesh only rarely thought to maintain it.

When I looked up, I saw that Shivaji's face was contorted with emotion. "I suppose," I said carefully, "that this would never have happened if you had been there."

He looked at me curiously, almost offended. "Of course not. I could never stand by and watch anyone die, much less the greatest genius India has produced in generations."

I nodded, and went back to my work.

3

As expected, the pressure suits caused the most difficulty. Like abyssal diving suits, they were constructed of rigid components, since it was necessary to for the occupant to be protected within a shell which could be maintained at standard pressure. Several areas called for unique solutions.

Even aerogels would have been insufficient insulation for the faceplate. We dealt with that problem by eliminating the faceplate altogether. Sensors built into the Daimonium sheath relayed the exterior scene to goggles worn by the occupant. Microchips tracked head and eye movement so that, visually at least, the explorer would have a completely unobstructed view in all directions. He would seem not to be wearing a helmet at all.

I found it impossible to protect all the

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hand joints from the heat and still leave the hands flexible enough to remove the data disks within the drone. We stepped around that problem by replacing the gloves with waldoes to be manipulated from within the protected sleeve.

That still left elbows, shoulders, knees, and hips unable to be protected by Daimonium. There was no elegant solution. Standard aerogel insulation reinforced by an intensified layer of microrefrigerant lines would have to do.

We were halfway through the pressure and temperature trials when a horrible thought occurred to me. I called Jagjit Ponnuru, the overall project manager for the retrieval effort.

"What are the entryway dimensions?" I asked.

On the screen of my tracy, Jagjit frowned at me as if I were asking a nonsensical question. "Large enough to allow egress of the Arachnid. I can get you the exact dimensions. How large do you want it?"

I shook my head. "Not the entryway of the landing vehicle. The entrance to the drone. My suits are going to be useless if they are too bulky to get to the data disks."

He blinked. "That is classified. I will have to get back to you."

That night, in bed, Sandy said, "Regina would never have allowed that sort of oversight in one of her projects."

I grunted agreement. But Regina was persona non grata on the project. Her only input was through occasional long-distance consulting. If Shivaji was aware that we were in sporadic communication, he chose not to make an issue of it.

It took Jagjit more that a week to get through the security bureaucracy. When he did, he obtained not only the dimensions of the entryway but also of the passage to the recording equipment.

It was too small. The suits we had built might fit through the hatch, but the wearer would be jammed into immobility at the first turn. We had to do a complete redesign.

Shivaji paid a surprise inspection two weeks later, when the rework was nearly complete. I expected a blustering harangue filled with threats concerning what would happen if we slipped schedule any further. Instead, he inspected the suits with something like awe.

"You would think these were robots," he said, his fingers tracing the opaque helmets, moving down to the hand waldoes. "You would never know that a human was inside. But . . . what is this?"

He had moved around to the back of the suit and was staring at the tightly curled bundles on the back. I felt my stomach tighten.

"My apologies," I said. "I thought my reports made it clear. The gaps in the Daimonium sheath throw a strain on the internal cooling system. The heat has to be dumped somewhere. That is what these vanes are for. They are radiating surfaces. The more heat they have to dump, the further they expand. Most of the time, of course, we want them to be rolled up and out of the way."

"Ingenious," he murmured. "Quite ingenious."

This era of good feeling lasted two days. Then he was in my office demanding that I fire Moe.

"Why?" I asked. "He is one of my best employees. He was the head of the surface team in Hawaii. I trusted him with my life."

"He is a follower of Islam." Shivaji's tone indicated that no more need be said.

"With a name like Mohammed el-Ghasib, he can hardly be accused of keeping it a secret."

"There is no peace between our people. We used to have a capital named New Delhi. Now we have a radioactive crater."

"They used to have a country called Pakistan. Now you have an additional province. It seems to me that you got the best of that deal." Then, realizing that I might have gone too far: "Look, Moe's people come from Saudi Arabia, and he

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was born in Berkeley, California. I am sure he can pass any security check—"

"He has already failed the only security check necessary. Fire him."

I could feel my temper evaporating. "This is simply wrong. You have hired the only team in existence able to keep your expedition from roasting before it touches the surface of Venus. Moe is part of that team."

"Unless he is gone by this evening, your contract will be terminated and you will all be removed."

"That would be self-destructive. Our work is by no means complete."

"If you have accomplished so little, you will be paid nothing."

The word that we were closing down got around quickly. When I got back to my trailer office after notifying the last of the work crews, Moe was waiting for me.

"Boss, I want you to know that I appreciate the stand you have taken."

I shook my head, feeling embarrassed. "Don't mention it. I'm not about to let some bigoted moron push my people around. That's not the way the Brothers taught me."

"But if there is one thing Janey and I have appreciated more, it has been being paid regularly. Until recently, that has been a sometimes proposition."

"I know," I said. "I appreciate the loyalty of everyone who has stood by me."

"So let's not throw it away just because some bureaucrat is a xenophobe. Here's a suggestion. Fire me to make Shivaji happy. Then appoint me your agent to handle all the deals we had lined up before Shivaji monopolized all our energies. I go back to the States and restart everything from the Moho probes to providing technical advice on the remake of *At the Earth's Core*. We all make more money than we would have otherwise, without the legal fight which might break us even if we eventually won."

I grimaced. "Shivaji shouldn't be able to push us around." I wanted that to sound noble. Somehow, even to my own ears, it sounded petulant.

Moe leaned across the desk and squeezed my shoulder as if I were a younger brother. "Absolutely right, in a perfect world. But this will be better for everyone. Do it as a favor for me."

Shivaji seemed almost disappointed when I told him the news. It was the last major disruption in our work. Less than a month later, we were undergoing our last premission briefing. I had thought myself prepared for all the major obstacles and dangers: the crushing pressure, the noxious atmosphere, the intense heat. Now I learned one last detail, caused by a conspiracy between our schedule and celestial mechanics.

We would be searching for the drone in the dark, in a night longer and more intense than any ever known on Earth.

4

On a notebook screen on the slopes of Mauna Loa, the *Indira Gandhi* had appeared to be a ten-story tower. In the intervening months, it had been given detail and substance, and become the spacecraft which would land us on Venus. Strapped into my cabin bunk, I had my first real opportunity to look past the engineering problems and personality clashes that had occupied my mind for most of ten weeks and consider the importance of our mission. It was almost too big to grasp. I could hardly comprehend the Cramers which were propelling us in-system at one *g*. We were emitting neutrinos at infinite velocity, tachyons if you will, which were pushing us forward as they fled away into the past. A little more than five years before, the first lab demonstration of a Cramer drive had rocked the world. Antigravity at no power cost! Cheap travel within the solar system, measured in terms of days and weeks rather than years. According to Regina, there were even plans to build floating cities, which would drift all over the Earth on its constantly changing winds.

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Now we were going after a technology compared to which Cramer drives were as primitive as sailing vessels. No wonder Shivaji had been pushing us so hard.

Colonel Sattayarak was our pilot. Near the end of our deceleration, he invited us into the lounge. The outer wall was a high definition screen. Right now it was displaying a white crescent which stretched from floor to ceiling.

"Is this working correctly?" Jagjit asked. "Shouldn't I be seeing cloud patterns?"

"You are too used to seeing those pictures taken in ultraviolet light," Shivaji said, not unkindly. "They print those in all the books, because the visible wavelength reality is too dull."

But it wasn't dull at all. The cloud cover glowed with the brilliant white of sulphuric acid droplets. Colonel Sattayarak told us to resume our stations for the descent. As I looked back on leaving the room, I though I could see pinpricks of light in the darkness far below. I wondered idly what they might be.

One of the nicer things about the Cramer drive was that there was no need for the ten *g* fireball reentry decelerations characteristic of chemical rockets. Sattayarak could drop us down gently as a feather if he wished. He would not so wish. At about seventy kilometers, we would encounter the top layer of sulphuric acid clouds. Even though the Russian Venera landers seemed to have succumbed to heat and pressure rather than the effects of acid, I did not want not want Daimonium exposed to the acid for a prolonged period. The good news was that the acid clouds ceased a little below fifty miles from the surface. The bad news was that they ceased because they evaporated before they hit the ground.

I lay strapped in my bunk, listening to the whisper of atmosphere grow to a dull roar, wishing Sandy and I were close enough to hold hands.

Weight had been increasing steadily. Suddenly, the straps bit into me as that weight was released. We had entered the upper cloud bank and Sattayarak was letting us drop. I wished our room had its own viewscreen, then chided myself for my forgetfulness. Outside, there would be only layer upon layer of darkness.

"David," Sandy said, "haven't we been falling for an awfully long—"

A thrumming vibration made itself felt through wall and cushions. I felt myself pressed down into the bunk.

"Those were the Cramers powering up," I said, trying not to sound as relieved as I felt. "I guess we won't crash after all."

The thrumming died away, but the sensation of weight remained. Abruptly, there was an almost imperceptible bump.

"Touchdown." Sattayarak's voice over the intercom sounded no more than slightly amused. "Welcome to Venus."

I unsnapped the safety harness and scrambled up to the control room, nearly banging my head on the companionway. Surface gravity might be almost nine-tenths of Earth's, but that missing one-tenth was, in close quarters, enough to make a painful difference. I held my hand up to every vent I passed to see if anything had gone immediately wrong. Reassuringly cool air washed across my palm each time.

As I crowded into the control room, Sattayarak was reading a series of numbers to Jagjit, who was methodically noting them down. Temperatures all along the inner hull. I found my station and checked the readings for the sensors monitoring the performance of the Daimonium itself. If integrity had somehow been compromised during the landing, I would probably note it here before the interior temperatures started to rise. With luck, I would see it soon enough for us to abort the mission and rise above the atmosphere before we all roasted.

"What was that?"

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I looked up at Jagjit, who was staring at the wall. "What was what?"

"That." The console trembled. There was a distant rumble, almost too low to hear. "That sound . . . like the footsteps of dinosaurs."

Sattayarak looked up patiently. "I, too, saw that movie when I was very young. I assure you, however, that there are no tyrannosaurs on Venus." Jagjit glared at him, angry but still frightened. Sattayarak sighed. "I have been hearing the same sound at irregular intervals since we landed. Whatever it is, it comes no nearer and gets no louder. It in no way threatens the stability of our vessel. For the moment, therefore, I believe we may ignore it."

"How close are you to finished up there?" Shivaji's voice over the intercom betrayed a carefully restrained impatience.

I looked over at the chronometer. It had taken more than half an hour to complete the landing checks. "Everything is fine here."

Jagjit looked over at Sattayarak and checked his screen one more time. "We are finished. Everything is optimal, so far."

"Then please release Mr. Maxwell to me. I do not want to be down here a minute longer than necessary."

At Jagjit's nod I left my station and took the moving ladder tubeway, which extended the full length of the ship, down to the hold. There lay the Arachnid, its legs folded about it to save room, its burnished skin gleaming in the dim hold lighting. I scrambled in, sealing the hatch behind me.

The plan from this point was simple. The drone lay on a ledge halfway up the side of a landform unique to Venus called a pancake dome. We had landed at its base. Although the sides were generally quite steep, intensive radar reconnaissance had discovered a twisting pathway up to the ledge with a slope no greater than thirty degrees. The Arachnid should be able to handle it easily.

Shivaji would enter the drone and remove the data disk. Sandy and I were along to make sure that all the cooling systems in both the Arachnid and the suits worked. In addition, Sandy would act as chauffeur, having qualified to drive the Arachnid in the preceding three months.

They had completed all their system checks while I had been up in the control room. As I was strapping myself in, Shivaji asked Sattayarak to pressurize the hold and open the main door. Hot carbon dioxide flooded the space around us, quickly increasing the pressure to ninety-two Earth atmospheres.

"Interior pressure is steady. No leaks," Sandy said. The temperature in the hold had climbed to five hundred degrees Centigrade. Inside the Arachnid, only cool air. The Daimonium, in fact all the systems, were functioning perfectly.

"Let's get going, then," Shivaji commanded. Joysticks flanked either side of Sandy's chair. She squeezed one of them. The Arachnid stretched its legs and walked down the ramp to the basalt of Venus.

Sudden brilliance cracked the sky into jagged plates. A few seconds later, the shockwave washed over us. The Arachnid quivered, but did not lose its balance.

"That is what Jagjit was hearing," I realized. "There has been a thunderstorm going on ever since we landed."

"It is no more than a distraction," Shivaji decided. "We are more than thirty kilometers below any rainfall. The wind speed is—?"

"Between one and two kilometers per hour," Sandy said.

"Not a factor, then. Proceed. Only you may wish to adjust the light intensification on our screens. The ground appears to be glowing on the current setting."

"You are getting an unenhanced outside image," I said, licking suddenly dry lips. "Parts of the ground are indeed glowing. It is only slightly below melting temperature."

The Arachnid advanced with a pranc-

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ing motion, intelligent shock absorbers keeping the cabin level and damping out all but forward motion. I programed the screen so that it would retain the images provided by the lightning and adjust them accordingly as we moved forward. Succeeding flashes extended the range of the image and corrected the program's bad guesses.

Static erupted from the speaker. ". . . ving troub . . . ceiving your telemetry . . ."

Shivaji activated his mike. "I'm having difficulty receiving your transmission. Say again."

This time the garble was even worse.

"It's the lightning storm," I said. "The static is drowning us out." I tried the other frequencies. Improvement was minimal. We could make ourselves understood, barely, at the base of the ramp. Half a kilometer away, nothing intelligible got through.

"Well, can we proceed?" Shivaji asked impatiently.

Sandy and I exchanged a glance, astonished that Shivaji was asking the question rather than just commanding us to go forward. On reflection, though, it made sense: Hounding project subordinates to make a schedule was one thing; strolling off onto into a ferociously hostile environment with malfunctioning equipment, however, might understandably induce a more conservative attitude.

"Things may look worse than they actually are," Sandy suggested. "Although we would like to have a working radio, it isn't necessary to the mission. After all, if the Arachnid breaks down, what can they do for us back at the ship? There is no backup Arachnid to come rescue us. The distance will be too far to walk in these suits. And if the *Indira Gandhi* could set down on the ledge where the drone is, we would have done so."

Shivaji grimaced. Lack of redundancy was an issue we had brought up before. In the end, Shivaji had ruled that he could not afford the extra time that it would have taken to send two ships, or to increase the size of the *Indira Gandhi* to make room for two Arachnids. He looked at me.

"We're here," I agreed. "Let's at least make the attempt. If any of the readings even get close to the danger zone, we head back."

Shivaji managed to make himself understood to Jagjit, and we set off again. All three of us were aware that, despite what I had said, if things actually started to go wrong, they might well do so with such speed that a leisurely retreat would be impossible.

The base of the dome was littered with rubble, platelike stone fragments which had apparently cracked off the upper reaches. The Arachnid lurched a few times as the debris shifted beneath its weight. Then we were on the slope beyond the loose rock and began our ascent.

It became quickly apparent that our radar maps, detailed as they were, were nonetheless misleading. There were gashes in the slope. Some of these crevasses were small enough that Sandy could make the Arachnid step across them. Others were too wide for that. After carefully walking the Arachnid along the edge to measure their depth and grade, Sandy took the Arachnid down one side and traversed the bottom until it came to the incline she had spotted earlier which it could negotiate to climb back to the surface.

Near the end of the ascent, the grade increase to nearly forty-five degrees. The Arachnid started up, then began to slide.

"Don't let it turn over!" Shivaji hissed.

Sandy fought the controls. As sophisticated as the Arachnid was, its design necessarily resulted in a high center of gravity. Movement brought out an inherent instability. Now, as it began to slide and twist, I found myself remembering how, as a child, I had come across an upside-down horseshoe crab, its small feet waving in the sun as it dried.

The upslope legs buckled at their top

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joints, so that the Arachnid fell toward the incline. There was a tremendous screeching as the craft slid the rest of the way down to the base of the slope. I waited for alarms. The displays showed that we were maintaining a steady interior temperature and cabin pressure. The only indication that we were in trouble was the slant of the deck.

Sandy was studying her instrument bank intently. "Hold on." She gripped both joysticks tightly, yanking back on one as she pushed the other forward. With a shudder and a lurch, the Arachnid stood up. The deck resumed the horizontal.

"We do not want to do that again," Shivaji said, his eyes very wide.

"I have no intention of doing so," Sandy replied. From where I sat, I could see that she had called up detailed images of the slope. False colors highlighted the relief. Various grooves and bumps were magnified, examined, and then replaced in the larger map, with lines showing the distances between them.

"What do you think?" Sandy asked.

"It looks doable," I said reluctantly.

"What—" Shivaji began.

"We were very proud of the *Pellucidar Express* when we first designed it," Sandy said, "but for all the sophistication of its sonars and its Daimonium sheathing, it was basically just a high-temperature bathyscaphe. This Arachnid is a much more sophisticated vehicle. I have failed to make use of its abilities until now."

She finished entering the final instructions. It responded on the console screen: PROGRAM COMPLETE. EXECUTE? Y/N. Shivaji was looking increasingly concerned. "You should not—"

Y ENTER.

I was thrown back in my seat as we surged forward. The cabin tilted for an instant as we hit the slope, then righted itself as the Arachnid put most of its weight onto its front legs. They searched for and found the footholds Sandy had identified. A few were rotten. The cabin shuddered as a rock gave way under the sudden weight of the vehicle. The motors powering the other legs whined as they took up the strain, thrusting the Arachnid up to the next set of holds.

And then we were on level ground again. The Arachnid was motionless, having come to the end of its programmed run. Ahead of us, at the end of this level space, lay a cylinder with rounded, tapered ends. It was perhaps three meters in diameter through its center and about twelve meters long.

"Well," said Shivaji, letting out his breath in a long sigh, "this is extraordinary. I really did not think you would make it." It was as close as he ever came to a compliment. "Let's get what we came for."

Although for safety reasons, each of us had individually fitted suits, the plan was for Sandy to stay at the controls of the Arachnid while Shivaji and I went outside to retrieve the data disk from the drone. Actually, Shivaji would retrieve the disk. I was going along to make sure our suits functioned properly and for extra muscle in case it was needed to open heat-swollen doors.

The suits were kept in a room beneath the main cabin. I sealed myself into my suit and initiated the automatic checking sequence. Small lights flashed contentedly in the lower left corner of my vision, keeping time with the shifting initials of each feature of the suit. Then there was only a single winking green light. I looked over at Shivaji. He had been right. With opaque helmets and mechanical hands, we were the classical images of robots.

"Transmission test. This is Maxwell. Everything is green."

"All green with Shivaji. Pressurize and open."

Sandy's confirmation was so clear in my helmet that she might have been standing right next to me. I felt heat around shoulders and elbows, knees

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and ankles. The cooling unit clicked on and the warmth faded away.

"Opening the exterior lock," Sandy warned.

A slice of the floor ahead of us dropped slowly away and became a ramp. I followed Shivaji down to the surface of Venus.

Immediately beneath the Arachnid, illuminated by the lights beneath its belly, there was ground indistinguishable to my nongeologist's eye from that which might have been seen in any stony desert on Earth. Two meters beyond the Arachnid's legs, the ground fell away vertically. Lightning spider-webbed the sky, and was reflected in the burnished hull. I looked out over a dark plain, dotted with dull red smudges. Despite the darkness, I was able to spot the *Indira Gandhi* almost immediately, a silvery column thrust up against the utter monotony of the burning bottomlands.

I felt rather than heard the impact. It hit me from behind, not a sharp blow but irresistible nonetheless, and I stumbled, leaned far out over the abyss, and began to fall—

Only to be grabbed and pulled back onto the ledge. "Don't go near the edge." Even this close to Shivaji, static crackled so loudly as to make him nearly unintelligible. "In this thick atmosphere, the nearer lightning flashes cause thunder to have as much force as a depth charge going off underwater."

He sounded as shaken as I felt. The radiating vanes on his back had partially unfolded, giving him the aspect of an as yet unclassified insect. As he spoke, another thunderclap rolled over us, a pressure almost like a sudden gust of wind. This time I was able to brace against it and remain upright.

I followed him carefully over to the drone, alert for any sign of a breach in the Daimonium sheathing of our suits. I could feel the surge of coolant around knees and elbows, even hear it as a distant whisper.

The drone, when we reached it, looked disappointingly ordinary for a prototype starship. Whatever had gone wrong had left most of the backup systems operational. It seemed to have set down and shut itself off without impacting on the surface. It was even oriented with the hatch facing us.

That was our last bit of luck. As expected, the hatch mechanism was not operational. Shivaji took a long, wedge-shaped tool from his belt, snapped it on to a waldo hand, and pried the hatch open. It stuck at about three centimeters, either because some interior mechanism had melted and was blocking it or because hatch and hull had swollen enough with the heat to throw the hatch off the interior track. I added my strength to Shivaji's. Together we pushed, pulled, and jiggled, and finally managed to slide the hatch all the way back. I stood aside then for Shivaji to enter.

Because the drone had been designed to operate in outer space without a crew, it had no airlock. A tunnel, less than a meter wide, ran from the hatch to the heart of the vessel: the autopilot which controlled the Cramers and the Maya drive. There was lodged the data disk which might hold the secret of interstellar flight. Or might contain the evidence which would prove it impossible.

Shivaji entered halfway, and stopped. "I can't get around the bend." He had to say it three times before I could understand him through the crackling static.

"Pull in your radiator vanes. They may be snagging."

He did so, and now was able to get completely inside. But not down the tunnel. I tried to imagine what the problem could be. We had rehearsed this procedure several times with a mockup. It should prove a tight fit, but by no means impossible.

"I'm getting hot." Shivaji backed out carefully and stood beside me. The vanes unfolded as if in relief. I examined him closely, wondering if despite our

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precautions something—the vanes or the tool belt—had come loose.

"This is the wrong suit," I said. "This is one of the set we designed before I got the entryway dimensions from Jagjit."

Shivaji was silent for so long that I thought he might not have heard me through the static. "This cannot be a mistake. It must be intentional. Sabotage."

Another pause. "Are you wearing the proper suit, Mr. Maxwell? If so, you should be able to retrieve the disk."

Had my own suit been switched, I would have noticed it. "Alright," I agreed. "It's the least I can do for the man who just saved my life."

I retracted the vanes on my suit and climbed in through the hatch. It was a tight fit, but I was able to crawl forward slowly on hands and knees, my way illuminated by the light on my helmet. Everything was the way it had been described at the end of the tunnel. Aside from a few readouts, now blank, there were two disk trays. The one on the left contained the flight program. The one on the right had all the data from five minutes before the flight started to system shutdown.

The trays had been designed to slide in and out at the touch of a button. That was not going to work without power, and restoring power under these conditions would have been difficult to impossible. Instead, I had been provided with a thin piece of metal with a small flange on the forward end. I was to attach this to a waldo, slide it under the tray, hook it, and pull it out manually.

To my astonishment, it worked the first time. The tray came out. With utmost delicacy, my waldo hand lifted the disk and deposited it in the pouch which had been specially designed for its safekeeping.

There was no room to turn around. I backed out slowly until my feet banged against the end of the tunnel. Then I extended my left foot, feeling for the hatch opening. It bumped against solid metal. I drew the leg up and tried again. Same result. I squeezed myself into a tight crouch, hoping that the illumination from my helmet might disclose the problem.

The hatch was closed. There was no inside latch or any other sort of opening mechanism. From this angle, in the uncertain light, I could barely see the hatch's outline.

Sweat stung my eyes. In this cramped space, there was no room for my radiating vanes to unfurl. Heat was building within my suit. If I did not get out quickly, I would cook.

"Shivaji! Open the hatch. Let me out!" There was no response. There was not even a crackle of static, which meant that I could not possibly be heard within the Arachnid.

The hatch had slid forward. If I pressed my left hand on the inner surface and shoved in that direction, I might force it open.

Only, of course, my hand was encased within the suit. The waldo was actually stronger than my hand, but it had no flat friction surfaces. Metal gouged metal with a chalk on blackboard shriek.

I collapsed, gasping. My vision was completely blurred. I could not think of anything else to try.

The hatch screeched open. Waldo hands lunged at me. I tried to duck aside.

"Don't fight me, damnit! We don't have much time." Even through the renewed static, I recognized Sandy's voice. She grabbed me under the arm and helped me out of the drone. I staggered and nearly fell.

"Keep moving," Sandy commanded. "We have to get behind that boulder."

I looked around for the Arachnid. It was nowhere in sight. "Why—?"

She pushed me down into a crouch between the boulder and the mountain wall. A flash, not from lightning, illuminated the whole rock face. Sand and pebbles blasted the wall, turning it into a miniature moonscape. The compression

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wave picked both of us up and slammed us against rock. The boulder sheltering us shuddered, and for an instant I wondered if it would smash into us.

It settled back into its original resting place. A quick shower of pebbles rained around us, two ringing sharply off my helmet. As it ended, I stood up and looked around. Neither the drone nor the Arachnid was in view. Haze limited vision to about twenty meters.

"Suit check," I ordered.

"Everything's green," Sandy said, after a few seconds. Remarkably, my suit was undamaged as well.

"Perhaps you could explain," I suggested. I tried to keep the tremor out of my voice.

"Shivaji called me out, saying that you had slipped off the edge of the cliff and were hanging on to a narrow ledge. I nearly panicked. You had warned me something like this might happen. I rushed out, hoping that you were still alive, keeping just enough of my wits about me to make sure Shivaji was not close enough to push me over the edge.

"Not that I had to worry about that, as it turned out. He must have scurried up the ramp of the Arachnid soon after I came down. I had just determined that there was no ledge beyond the cliff edge and was returning to the Arachnid when I heard the screeching come from inside the drone. I realized that you had to be inside. While I was trying to pull open the hatch, I noticed the package attached to the base of the hull. Our briefings hadn't shown anything like that on the drone. I guess that's why I understood immediately that it was a bomb."

The haze was thinning slowly as dust settled out of the atmosphere. Lightning traced fractal patterns across the blackness above. The plain below continued its impression of a calm day in Hell. The Arachnid was invisible somewhere down there. I wondered if Shivaji would be able to drive it skillfully enough to get back to the *Indira Gandhi*. One certain thing was that our air supply would never last if we attempted to walk back.

"You were right about Shivaji," Sandy continued. "I guess it's time to see if you are right about insect evolution as well.

"Flight configuration: activate!"

The heat radiation vanes on her back unfolded to their full extent and snapped taut. Now you could see that the back, or upper, surface was slightly rounded in a way which would have delighted Daniel Bernoulli had he lived to see it. Back on Earth, it had seemed simple and obvious. Insect wings, it was said, were a case of evolutionary preadaptation, heat radiating surfaces which just happened to be useful for flight. A just-so story, it had always seemed to me, to save scientists from the nightmare of teleology. Yet in this case, useful both as a design inspiration and a concealment. They would never have worked on Earth. But on Venus, with its lower gravity and immensely thicker atmosphere, they should.

If you could believe the computer simulations.

Sandy seemed to understand my hesitation. "Have faith in your work, hon. I do." With that, she leapt into the darkness. I snapped open my wings and followed, not certain they would work, but absolutely certain that there would be no point in continuing to live if they did not.

5

Shivaji exited the Arachnid in the *Indira Gandhi*'s hold. Catching sight of Jagjit, he began a story of odd readings from the drone, how Sandy and I had insisted on performing some measurements before he could reach the craft, and how it had blown up in our faces. I don't know how he was going to rationalize it. Perhaps something about how the strains of Maya space had made the craft convert to antimatter, or some such.

Then he looked around and saw Sandy and me. The words stopped. No

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false delight at seeing us alive. No attempted denials or explanations. Just silence, and a look of stoic resignation.

Colonel Sattayarak stepped forward and informed him that he was being placed under arrest pursuant to the Sabotage and Sedition Act of 2012. I tensed, expecting a fight. Instead, Shivaji allowed himself to be led to his room and locked in.

I saw him once more on the flight back to Earth. Sattayarak unlocked the door to Shivaji's room, let me in, and locked it behind me. The room intercom had been turned on from the bridge. Every word we said would be recorded.

Shivaji was sitting on his bunk, staring at the wall. His eyes darted in my direction when I entered, then returned to the wall. I leaned against the door. All furniture, indeed anything moveable which might have served as a weapon, had been removed. There were no sheets on the bunk.

"I am curious," I said, after a few moments of silence. "I can understand why you might not like Sandy or myself. Neither of us is Hindu, or even Indian. Sandy suffers from the additional disadvantage of her sex."

That drew a quick look, gone almost before it registered.

"So if you decided eliminate us and take all the glory for yourself, I can almost comprehend your motivation. What I cannot understand is why you were willing to sacrifice the data disk, with which your country may lead humanity to the stars. I cannot understand why you killed the greatest genius your country had produced this century, Ramesh Sadanada."

That was the reason I was talking to him. Neither Sattayarak nor Jagjit had believed me when I first suggested that Shivaji had killed Ramesh even as he had tried to kill me. But when I explained everything which had made me uneasy about Shivaji, and which had led me to reinforce the suits with bulletproof mesh and provide them radiating surfaces which could double as wings, they agreed to allow the attempt.

"I did not want to hurt anyone." Shivaji's voice was a dry whisper. His eyes blinked rapidly. "I wanted to save India. I wanted to save the human race."

"How would these deaths have saved the human race?" The easy answer, the answer Jagjit was inclined to accept, was that Shivaji had simply gone crazy. Somehow, I did not believe it.

He shook his head. "Nobody was supposed to be hurt," he insisted. "I altered the control code in the drone so that it would plunge into Venus' atmosphere. I didn't know there was a safety default which would make it slow and land.

"I had myself put in charge of the rescue effort. It was a difficult situation. I had to be seen making all efforts to recover the drone while doing all I could to frustrate the endeavor. I contracted with the House of Hawks, certain that Hallaj would fail to find a way to withstand the heat of Venus. She found you. I thought that I could misdirect your efforts by withholding key information. Hallaj, with her monkeylike curiosity, foiled most, though not all, of that plan.

"Then I thought that I could make the term of service so displeasing that you would quit. I failed to realize that greed would overcome anger and shame, even after I forced you to remove one of your key workers.

"Now I was desperate. My final fallback was to delay the retrieval effort by any means possible, hoping that in the interval I would find a way to quash it entirely. If our land vehicle were unable to ascend the dome, and I had been privately assured that parts of the slope were beyond its capabilities, we would not be able to reach the drone. If our suits were just barely too large to fit inside, we would have to return without the data disks.

"Unfortunately, you anticipated or overcame these obstacles. By the time

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we reached the ledge, the only option I had left was to destroy the drone. And the two of you as well."

The regret in his voice sounded real. I found myself thinking of a doctor explaining to a patient that his leg would have to be amputated.

"You still have not told me why."

Shivaji looked away from me. "There was a philosopher who said that he was terrified by the silence of infinite spaces. He was a fool. That silence, that seeming infinity, was our greatest protection. Our only protection. Which the Maya drive destroys. It screams "here we are" to a universe which has happily ignored us up to now."

He got up and paced, as much as he could in that confined space. Two steps, two steps, two steps. "The age of the universe is such that we cannot be the first intelligent race, or even the first to invent the Maya drive. Some of them must be unimaginably advanced compared to us. It is too much to hope for that they will continue to ignore us once we begin to blunder around their worlds.

"My countrymen learned long ago the fate of less powerful civilizations once the ocean became a highway instead of a barrier. The only question is, which will be worse, those who wish to do good to us, or those who see us as vermin to be exterminated."

"It could never have worked," I said, after a moment's silence. "Even with us, even with Ramesh dead, there was still Yamaoka. Ramesh said that he was responsible for turning theory into functioning machinery."

"You are right, of course," Shivaji said, nodding convulsively. "I would have to have used my contacts in Intelligence to dispose of that problem."

I shuddered and turned to leave. That was when the inconsistency leapt out at me. "If you realized I would have to die as soon as we reached the ledge, why did you pull me back when I started to fall? Why did you save my life?"

For the first time, I found myself able to read a totally unambiguous emotion on his face. Shame. The shame of a soldier who knows himself a coward.

"It was a reflex. I wasn't thinking." He ducked his head away, as if expecting me to chastise him.

6

I met Shivaji one more time, thirty years later. It was in the huge Von Braun orbital complex that served as a transfer point for much of Earth's interplanetary traffic. I had just been pulled back from Mercury where Maxwell Enterprises had been a subcontractor on an effort to built a fortified subterranean command post the size of a small city. We had been working continuous shifts on what was described as the most important project for the survival of the human race. Then, without explanation, they terminated the project. Some of my co-workers assured me that this meant there would be no war with the Gatherers, the strange alliance of races we had discovered toward the center of the galaxy.

The word was that it would be at least a day before I could get off Von Braun. Most of the shuttles had been commandeered for military use. With the hundreds of other workers just dumped onto the station, I was awaiting my turn to leave. I sent a message to Sandy, notifying her of the delay. Then I settled myself in for a long wait in the Hub lounge, hitching myself to an empty space on the wall and gazing at an Earth which seemed impossibly far away.

When my tracy bleeped at me, I at first thought at first that Sandy was returning my call. Instead, the readout informed me that Chandra Shivaji had noticed my presence on-station and requested the pleasure of my company.

My immediate reaction was to wipe the message from memory and ignore it. What could he possibly want with me? Could it be some long-delayed revenge? Staying in the lounge was undoubtedly the safest thing to do. And yet . . .

I queried MediaCore on Shivaji. The

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little it came up with confirmed my spotty memory. He had been convicted of two counts of attempted murder and sabotage. He was never charged with Ramesh's death. The verdict had been ten years imprisonment and what was delicately referred to as "psychological restructuring."

Yet Shivaji still had political allies. There was a short notice of his release less than four years after his incarceration. Psychological restructuring was not mentioned.

Stranded passengers crowded the lounge. Cool air from the ventilation system fought a losing battle with so much body heat. Feet and elbows jabbed into me at odd angles.

I was bored. And curious.

I notified the Von Braun Directory of my destination and instructed it to page me half an hour before my shuttle arrived. Then I unhooked myself from the wall and, trying not to put my foot in anyone's face, kicked over to the elevator banks.

The original Von Braun had been constructed according to an old, old plan. An inner docking hub connected to a spinning outer torus by four steel arms. It had expanded with increasing traffic, filling outward, at first with low-*g* storage, and then with autofactories, laboratories, and living quarters. It was now a solid disk, and plans already approved and funded called for it to expand into a cylinder in the course of the next two decades.

My destination was just one level inward from the original outer ring. Though gravity here was less than one *g*, I still suffered the effects of months of work on Mercury. I felt like lead and had to move carefully.

My tracy led me antispinward along the main corridor to a door marked only by a plaque which read 2K133. I identified myself to the door and it opened.

The room was small but luxurious. One entire wall was an omni-screen; the other three were covered by expensive wall-hangings designed by Valada. A single doorway led to a bedroom through in which a further door could be seen, presumably the bathroom. Warm, moist air flowed out into the corridor.

"Mr. Maxwell! Wel-welcome to my quarters. I feared you would decline my invitation." Shivaji seemed uneasy, almost embarrassed. That, oddly enough, put me at ease. I could not believe that someone so socially disconcerted would be a real danger.

"I was curious," I said.

He nodded, as if that explained everything, and invited me in. He cleared data disks and print outs, some of which were letters, other which appeared to be fragments of a longer work, from a low table to make room for tea. I sipped slowly, feeling myself relax.

"It was a shock to see your name on the list of transients." Shivaji nodded toward the blank omni-screen. "I had been thinking of you. Today is an anniversary."

He waited to see if I remembered. "Ramesh's death," I said, though I had not made the connection before that moment.

"You were more direct at our last meeting," he said reprovingly. "Ramesh's murder. You asked me how I could have killed the brightest intellect my race had produced in a century. My explanation made little impression, I fear. Perhaps it will now. I have something to show you."

It was as if the wall suddenly disappeared, leaving us exposed to interplanetary space. I held my breath, my hindbrain expecting the room to depressurize even as I realized that the omni-screen had been activated.

"This a SPADEF outpost called Chokepoint. I received this record twelve hours ago. The Executive is undoubtedly wondering when, if ever, to make it public."

In his tone of voice, the unstated message that even in exile he had important friends, that he himself was still to some degree important because of them.

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I blinked. Pinpricks of painful brilliance seemed to leap from the screen like laser beams.

"The battle begins," Shivaji said softly.

The point of view changed abruptly. I was looking at a blue-green world flecked with white. "Faux Terra," Shivaji said. "An oxygen-rich world much like Earth."

Points of light appeared all over the globe, blossomed, came together. "The Gatherers think it is Earth. They have ignited the atmosphere," Shivaji said. The world blazed like a huge comet. Portions of the surface began to erupt and hurtle themselves into space.

The recording ended abruptly. "Torching the planet was apparently insufficient. The battle climaxed with the explosion of Faux Terra's sun. It is uncertain how long our deception will remain effective."

The recording moved back to the image of the burning planet and froze on it. "This is what I feared. This is what may yet happen to Earth. Now I charge you, Mr. Maxwell, to answer honestly. Thirty years ago, you were a brave man. I believe you would be willing to give your life to prevent the extinction of our race."

I nodded slowly, unable to speak, transfixed by the image of the burning world.

"Then how can you say that the prevention of this was not worth a handful of lives? Even if one was sweet and innocent and the greatest genius of his time."

This was what this meeting was all about. An attempt to receive forgiveness and, more than that, vindication, from a man who had been his enemy. In exile, Shivaji was still active, writing to friends still in power, preparing his memoirs and publishing articles commenting on current affairs. He was trying to rebuild himself, much as Richard Nixon had two centuries ago.

For an instant, what he said sounded so reasonable, so obviously correct, that I found myself agreeing with him, willing to give him the benediction he sought.

Then I shook my head. Thirty years before, the universe might have been empty of other intelligent life, or any others might have been friendly, or if evil, they might have been so technologically inferior that we could have ignored them. Killing Ramesh was committing an actual evil to prevent a speculative harm.

Further, it supposed that with Ramesh dead we would never have encountered the Gatherers and that no one else would ever have discovered the theoretical framework for the Maya drive. Neither conjecture was certain, and the latter was almost certainly false. Scientific and technological advances could be postponed, perhaps, but they could no more be repressed forever than King Canute could command the tide to stay.

And finally there was the question which had challenged rabbis and philosophers and moral theologians for centuries. Is it justifiable for the good of the many that one innocent should be made to suffer? In that instant, I knew that the issue was beyond calculation. Even the whole human race was not worth the murder of one innocent.

I tried to tell Shivaji some of this, stumbling over words which seemed like so many ill-fitting blocks of wood. He sighed when I finished.

"Then it is as I feared," he said, a look almost of pity in his eyes. "You are a fanatic." ◘

The author wishes to thank David Grinspoon and Scott Rowland for answering queries concerning Venus and volcanoes. Any howling blunders are obviously the creative input of the author.

EDITOR'S NOTE: This story is a prequel to "Bearings" (December 1986) and "In the Dazzle" (June 1994).

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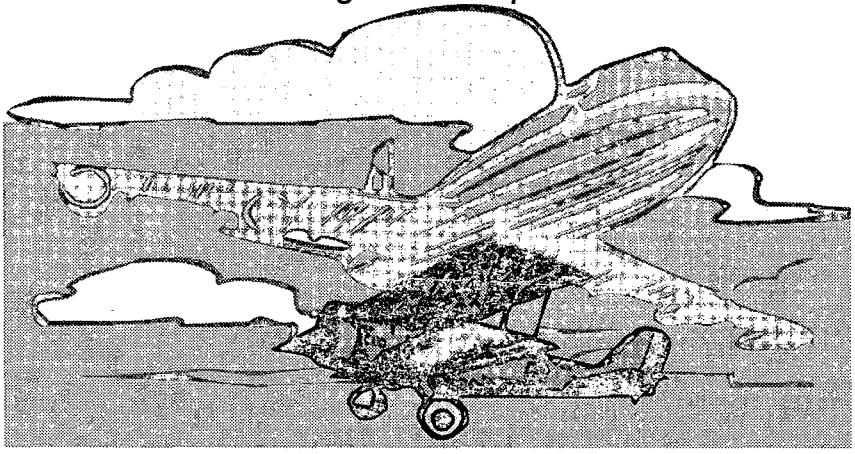
Hugh David

REVOLUTION IN THE AIR

We've all heard that air traffic control too often depends on obsolete equipment and methods. How might it be improved?



Almost as soon as aircraft finally staggered off the ground, people began worrying about how to prevent them running into each other. At first, the traditional rules for avoiding collision at sea were adapted to the air, with hilarious results. A book published just before the start of the First World War contains the proposed rule:

> When flying in daylight, and finding himself in distress, it is advised that a pilot should show a red triangular flag, and at the same time suspend from his machine two black balls, hung one above another.

Perhaps fortunately, this set of rules was overtaken by events.

Air Traffic Control (ATC) only really got off the ground, so to speak, between the First and Second World Wars. Simplifying considerably, pilots flew aircraft along routes which were marked on the ground by beacons. These beacons were originally huts marked with an identity code, supplemented by colored lights, and open fires at night. These were later replaced by radio transmitters, which meant that aircraft could fly without having to look out of the window, particularly in fog or bad weather. Unfortunately, there was no way to avoid other aircraft, apart from keeping a good lookout, which didn't work in cloud or fog, or at night. Air Traffic Control came into being to ensure that aircraft didn't run into each other. (Even today there is a basic distinction between flying under Visual Flight Rules, where it is up to you where you go, and Instrument Flight Rules, where Air Traffic Control tells you where to go.) Initially a separate height was assigned to each flight, before the aircraft took off. When radio became practical in aircraft, the air

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traffic controller was able to assign levels to aircraft in flight, and to receive messages from the aircraft reporting their passage over beacons.

Controllers needed to know what the aircraft wanted to do. Initially, the only information available was the Flight Plan, which tells the controllers what the aircraft is, where it is going, when it expects to do it, and so on, down to whether lifebelts are provided for the passengers. The International Civil Aviation Organization agreed on a standard form for the Flight Plan some fifty years ago, and it has not changed much since then. Pilots file flight plans before takeoff, and they are sent by a special teleprinter network to all the centers (Terminal Areas or Upper Airspace Centers—the names differ from place to place, but essentially these are the places you get into the air and back to the ground, and the bits in between where you are just cruising along). At the center, Flight Strips are produced for each sector through which the aircraft will pass. Flight Strips are usually about an inch high and six or eight inches long, and have the basic data about the aircraft written on them—the callsign, type, origin, destination, requested flight level, and estimated times and heights at selected beacons along its route. The strips are mounted in strip holders, which may be colored to indicate the general direction of flight, and sorted and placed on a "strip board"—a set of inclined racks, where the planner compares them to detect potential conflicts, and check entry and exit conditions. Planners usually solve conflicts by moving aircraft to higher or lower levels.

After the Second World War, radar systems became available. These allowed the controller to obtain an idea of where the aircraft really were, as against where they thought or said they were. Secondary Surveillance Radar, developed from the military Identification Friend or Foe, was introduced which allowed the ground system to interrogate the aircraft and find out who they were and at what height they were flying. The original controller became a Procedural Controller (Planner) coordinating entry and exit conditions with the neighboring sectors and solving potential conflicts by allocating changed levels to the aircraft. He (or very rarely she) was assisted by a Radar controller (Executive), who relayed his orders to the aircraft at the appropriate time, watched the radar, and intervened to correct errors or vector aircraft to avoid conflicts. (Roughly speaking a conflict occurs when two aircraft come closer than five nautical miles without having adequate height separation. Controllers don't like to talk or think about collisions.)

Computers were initially brought in to help handle the Flight Plan data, and to print strips automatically. More or less at the same time, systems were developed to combine the data from several radars to obtain a better idea of where the aircraft actually were. These systems were computer-based, and it was a short step, although technically difficult, to match the radar and flight plan data, so that the radar controller could be provided with flight plan data in a little label attached to the aircraft symbol on his screen. If the label contained the whole flight plan, there would be no room for anything else on the screen, so only the most vital items, such as the call-sign, the current height and the height the aircraft is climbing or descending to are shown. At present, this about all that most of the world's ATC systems can do.

A new generation of ATC systems is being designed, which use the flexibility of computer systems to provide "electronic flight strips" and other goodies. Unfortunately, controllers don't like these systems. They love "Conflict Risk Displays" which warn them that aircraft will be in conflict at some future time, but they hate "electronic flight strips." This is because they cannot use them as they do the paper ones, marking changes of flight level, pushing them to

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one side as a reminder that something needs to be done, or taking a handful of strips to compare levels and times over a particular beacon.

The Horseless Carriage Effect

This is an example of the "horseless carriage" effect. In order to ease perceptual problems in the transition from traditional electromechanical to digital systems, it is tempting to reproduce the traditional image on the display screen. This can be a recipe for disaster. The image you get on a flat display screen stands out less than what you can see on a bank of dials or paper strips, so that minor but critical differences can be overlooked. There have been many similar short-sighted adaptations of pre-computer displays. They have some superficial attractions. The designer doesn't have to think about what the system is actually for, or what the users really want or need. The displays look sufficiently like the existing system that no training or transition period seems necessary. Often neither of these is true, but, by the time this becomes apparent, the system is in place.

If you look back at the way that ATC systems have developed, you will see that "gadgets" of one sort or another have been developed, then applied to help the controller. The system has simply "just grown." No one has ever looked systematically at what ATC is for, and how the tasks could, or should, be divided between human and computer elements in the system. Complacent managers call this "evolving," forgetting that "evolution" involves the mindless generation of variation, combined with the ruthless culling of the less well-adapted.

Beyond the Interface

I propose a different approach to the development of these systems. None of the individual elements of this approach is unprecedented, and most of what I am saying can be derived from various studies, ranging from neurophysiology to anthropology to systems analysis, carried out in the last twenty-five to thirty years.

Task Definition

The starting point of interface design should be a careful, in-depth study of what are the real purposes of the control system being investigated. Most organizations have a standard definition, which will be recited in answer to the initial question. In ATC, this is usually "The safe, orderly, and economic control of air traffic." If, however, you analyze the components of this statement, you find that the first is a constraint, the second is a practical requirement of pre-computerized systems arising from the limits of human memory and information processing capacity, and the third is often a pious hope rather than a realistic goal. Although it is always possible to argue over abstract definitions, ATC's purpose can be defined as to allow air traffic to fly from origin to destination as quickly and/or cheaply as the individual flights require, with the minimum disturbance necessary to maintain safety. (It is often worthwhile looking to see if there are additional services that a system could provide without significant extra cost, or if there are some services that are provided that aren't wanted, needed or justified. But that is another story.)

Task Analysis

The second stage of the process is to analyze the "real" task. This may well not be closely related to the formal task as traditionally defined. It is particularly important to distinguish between a task "analysis" and a task "description." A "task description" requires observation of the existing system, often in extraordinary detail (Phillips et al. 1984), and usually has the unfortunate consequence of producing a mental "set" in favor of the existing method of control. For simplicity and convenience, we will look at "en-route" ATC, which concerns aircraft in

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Figure 1
Task list for contemporary "en-route" controller

Number	Nature of Task
1	"learn" sectors
2	manipulate and mark strips
3	plan future streams of aircraft entering their sectors
4	check that they will not conflict within the sector
5	determine how to resolve conflicts
6	match radar images to strips
7	acknowledge aircraft entering the sector
8	intervene to resolve conflicts
9	coordinate their actions with the next sector
10	monitor aircraft behavior for deviations from track
11	hand aircraft over to the next sector
12	attempt to comply with any special requests
13	handle unexpected emergencies.

the major part of their flight, after they have left the region around their airport of origin, and before they arrive at their destination. The Terminal Maneuvering Areas around airports or groups of airports have their own problems.

Figure 1 (based on Dee 1996) sketches the tasks currently carried out by en-route Air Traffic Controllers.

It would be too boring to carry out a systematic analysis of these tasks (See David 1997). The first task—"learning sectors" is particularly interesting from an ergonomic[1] point of view. It takes a fully trained controller about six months to "learn" a sector. The controller accompanies an experienced controller on the sector, apparently absorbing a vast quantity of information about the sector, the usual traffic and its peculiarities, so that this information is in his permanent memory for recall. The necessity for this feat of memorization is a criticism of the current systems of training and information presentation. This information is a considerable burden to the controller, fading rapidly after a few days' interruption of the task. Many "coping strategies" are required to maintain it, even with the present level of traffic (Stein and Bailey 1994).

Many of the tasks in Figure 1 are essentially routine, linked to the traditional methods of radio communication which take up a considerable proportion of the controllers' time. Others reflect the need to match the strip or tabular data on which planning is based, and the decisions arrived at during planning, to the image of the current situation presented by the annotated radar display. This operation is inherently wasteful, since the computer has already done it. Some modern stripless systems (Graham et al. 1994) eliminate this part of the workload by displaying the "strip" data as part of an aircraft label. This approach has other drawbacks—it covers the screen with tabular data, or requires separate windows to be opened for each aircraft.

Communication

Radio communication is inherently error-prone. Attempts to achieve mechanical levels of reliability by drilling human operators are futile and inhumane. Cushing (1994) draws on reports of the (US) National Traffic Safety Board, and the Aviation Safety Reporting System, to show that this form of communication is no longer viable. He sketches a potential "datalink" alternative.

Human Tasks

To summarize an extensive argument,

[1] "Ergonomics" is the European name for the design of equipment suited to the user. Human Factors is the US equivalent. (Alternatively, Human Factors Engineers are Bosses' men, Ergonomists are Workers' men.) I am an ergonomist.

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the tasks particularly suited to, and enjoyed by human operators are conflict resolution (but not conflict detection), dealing with special requests from aircraft, and rectifying errors identified by computer monitoring of traffic, such as may arise from incorrectly set Flight Management Systems. Controllers are also good at imposing a strategic direction on the system, by developing and applying conventions to reduce workload and increase overall efficiency.

The human-computer interface should therefore be designed to make it easy to do these tasks, making the data necessary for these tasks easily accessible, while not stopping the controller from looking further into the data when opportunity offers, or chatting to pilots if he feels so inclined. As Woods (1995) remarks, the now traditional windowing structure is not well-adapted for dynamic control, since it requires the user to search out the correct window to find the data or formulate the instruction required. It is far better, if at all possible, to show all necessary information on one screen. This may at first seem a difficult task, but it is not impossible if the nature of the data and the way they are used are taken into account.

The Data

We can simplify the actual ATC situation by considering the trajectory of each aircraft as a series of linked straight-line segments. (Engineers tend to get upset at this point, since they pride themselves in making precise trajectory estimates, taking into account almost everything you could think of, down to and including company policy. Since we are dealing with separations measured in miles, it is more useful to have a simple, easy-to-handle definition, than 1-meter accuracy.) Each segment begins with a position in space, expressed as X, Y, and H coordinates, and a (constant) rate of change of each of these. The position is true at a time T and the segment continues until one or more of the rates of change alter after an interval DT. Segments before the current time are fixed, and of no immediate interest for control purposes. Future segments describe the planned future path of the aircraft. These can be compared with the future segments of other aircraft to identify losses of separation at future times. The use of straight-line segments permits a very simple conflict detection algorithm to be employed, which is critical to the success of the method. Changes in future flight path can be specified simply, and converted into an alternative sequence of segments, which can be tested to identify new or remaining conflicts.

Traditional displays

There are two traditional means of displaying air traffic data. The radar image displays the current X and Y dimensions as positions on the display surface, dX and dY by a "speed vector" or a trail of dots (more "horseless-carriage" conversion) and codes height (H) as a three-digit number displayed close to the aircraft marker, in a "label" containing the call sign, and various other data expressed as letters and digits. The strip display (usually) reduces the X and Y dimensions to a series of named points (usually beacons where routes intersect) for which estimated times (T) and heights (H) are specified as numeric values. The strips themselves may be arranged in various ways, for example, under a label for the next beacon, arranged by height or estimated time, where the labels are arranged in a roughly geographical layout. It is very difficult to cope with aircraft which do not follow predefined routes if you are using a striplike display.

Apart from the position and speed vector, virtually all the data are presented in letters and digits. To complicate matters further, beacons are usually shown on the radar by abbreviations, if they are labeled at all, and spoken as their full names. Commercial flight call signs contain a company identifier such

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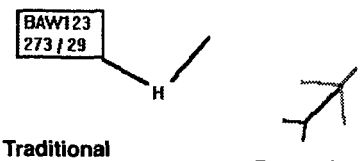
Figure 2



Traditional Radar Image

Revised Image

as PA for Pan American Airways, which was spoken as "Clipper" and a flight number. You could have PA804, PA814 and PA840 all present at the same time, with BA804 (Speedbird 804), etc. to add to the fun.

From the cognitive point of view, this is a mess. If the theories of cerebral asymmetry of cognitive function (Springer and Deutsch 1993) have any validity, it would be hard to design a worse display system. Graphical and textual indicators are scrambled together unsystematically. In some systems, rates of climb, known to the computer system to a high degree of accuracy, are deducible only by watching the rate at which the last digit, representing hundreds of feet, changes. If, as is usually the case, the display is updated only at ten-second intervals, it may take up to a minute to obtain even an approximate idea of the climb rate. Controllers adapt to this by learning the trajectories to be expected of common types of aircraft in the hands of particular company pilots, and by allowing enormous safety margins (Lafon-Millon 1978).

Conflicts, the main justification for en-route air traffic control, are usually not shown to the controller. (Some systems have last-moment short-term conflict alerts, but many of these rely only on radar data, so that they cannot cope with aircraft which have been instructed to cease climbing below the level of the opposing traffic, for example, and generate many false alarms.) In the ODID (Prosser et al. 1991, Graham et al. 1995) research simulations, a Conflict Risk Display was provided which consisted of:

—A rectangular display showing time-to-go as the horizontal and minimum separation as the vertical axis. Numbered points identified unsolved conflicts. A horizontal line shows time for which the two aircraft will be closer than the minimum separation—usually five nautical miles.

—A table showing the call signs of the pairs of aircraft involved in each conflict.

To resolve a conflict, the controller made a mental note of the number, referred to the table, made a mental note of the two call signs, then searched the radar display to find the two aircraft involved. He then estimated their relative speeds, noted their heights, checked or recalled their future trajectories, and estimated their relative positions at the time of conflict. (It is often easier to solve a conflict by maneuvering the aircraft which passes behind the other.) Experienced controllers would scan the table of call signs to see if one aircraft was involved in several conflicts, and search for a maneuver which would solve them all. This display was greatly liked by controllers. This was probably

Figure 3

Datum	Traditional	Revised
Identity	Call sign	Select a/c by mouse
Heading	Speed vector	Direction of icon body
Size	Symbol code (H=heavy)	Size of symbol
Speed	Vector length	Wing sweep
Height	3-digit code	Color
Attitude	Symbol + final level	Color combination

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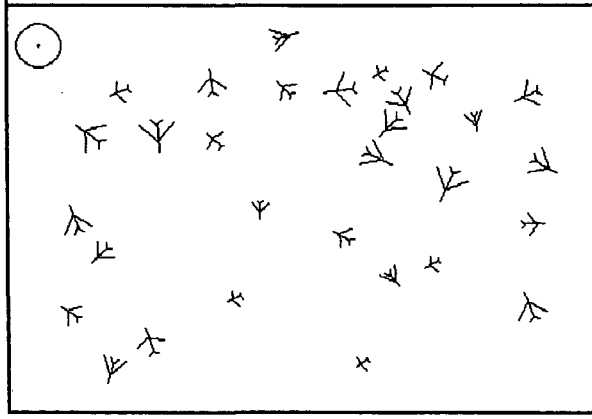
because it was usually blank, assuring them that that they had not missed a conflict in their normal scanning of the display, a constant background fear of all controllers.

Figure 4
Thirty random aircraft (spot the nine in conflict)



Revised display

We will assume that we use a maplike display as our primary display, showing aircraft at positions by symbols. Figure 2 shows a representative contemporary and a revised aircraft symbol.

Figure 3 lists the aspects displayed, before and after redesign.

Height is indicated by color coding. Eastbound cruising levels are shades of yellow, westbound are shades of blue. Aircraft in level flight are normally at a fixed level, and are colored accordingly. Aircraft climbing or descending have the front end in the level they are approaching, and their rear in that they are leaving. The speed indication is highly approximate, but is rarely significant (see below).

Figure 4 shows a representative screen, as displayed on a rather primitive VGA display. There are 30 aircraft in random flight on this display. (Because *Analog* is not yet able to provide color illustrations, I have made up monochrome images to show the principles—showing black symbols on a white background. These would normally be multicolored symbols on a dark background.) All these aircraft are in level flight at the same level (FL350 = 35,000 feet). The circle in the top left corner has a radius of five nautical miles. No aircraft should pass within this distance of another. Nine of these aircraft will do so.

(*The reader is invited to try to identify the aircraft in conflicts on Figure 4 before looking at Figure 5.*)

Figure 5 also shows a logical extension of the simplification process, where aircraft that are not involved in conflicts are not shown to the controller. Most aircraft would pass through the airspace without contacting the controller at all. (We have already upset the engineers. This really upsets the controllers. One referee described this as "crazy." But, to quote Niels Bohr, is it crazy enough? Do you have to tell your mobile phone company when you move from one transmitter to another?)

(Now try to identify the seven conflicts before looking at Figure 6.)

Figure 6 shows the potential conflicts present in this image. Conflicts are displayed by linking the aircraft involved. This leads the eye to the aircraft most involved in conflicts. Lines linking conflicts are made more salient as the time to go before loss of separation becomes shorter, turning bright red when really urgent.

At present, future conflicts are often first detected by the Planner, when comparing strips. He may annotate a strip to tell the Executive to move the

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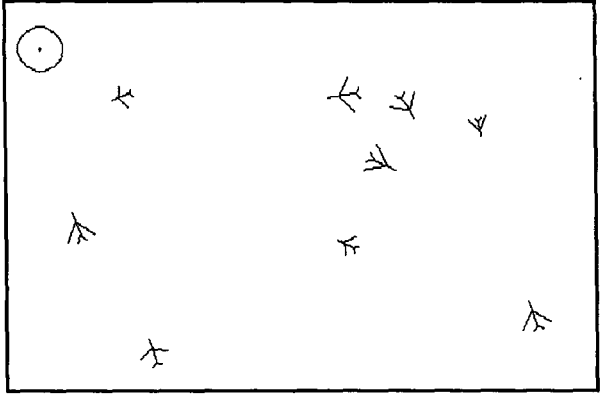
Figure 5
Nine aircraft in conflict (spot the seven conflicts)



aircraft to a higher or lower level before a certain beacon. Since he cannot be certain exactly when the Executive will make the move, both levels may be blocked for a considerable time. To resolve conflicts, instructions must be given to one or more aircraft. The Executive must estimate a sufficient diversion from track to respect the required separation. For safety's sake, he always overestimates. Where the separation minimum is five miles, he usually adds "two more for the wife and kids." Where aircraft are climbing or descending, he usually reserves all the levels from the start to the end of the level change. The Executive gives instructions, by radio, to be executed more or less immediately by the pilot. He must monitor the pilot's reply, to be sure that his order has been correctly received. He must check on the radar a minute or so later that the aircraft is actually doing what he asked. He must note, or remember, when he has altered the track of an aircraft, in order to return it to track or height later.

The future system will allow the controller to choose which aircraft he will maneuver, but the system can be set up to offer the next aircraft according to pre-defined criteria. In the currently available demonstrator, the pair of aircraft which will first lose separation is selected, then, within that pair:

—The aircraft involved in most conflicts.

—The aircraft that is not at the level it wishes to leave the area at.

—The aircraft that has furthest to go before leaving—because this is easiest to return to track after a maneuver.

(Before looking at Figure 7, the reader is invited to try to decide which aircraft the system chose.)

Having selected an aircraft, the system shows its future trajectory superimposed on the display, with the trajectories of conflicting aircraft, and their relative positions at closest approach. (These are not easy to see on Figure 7—color coding makes them very clear on the demonstrator.) An auxiliary display shows the flight profile of the aircraft, with a horizontal scale representing distance to the same scale as the main display, (one dash represents one minute's flying time) and a vertical scale showing the heights (flight levels) available. Solid blocks represent aircraft which will be in conflict, and hollow blocks represent aircraft which pass over or under the flight, and therefore could be in conflict if the flight level is changed. (We've tried 3D perspective displays. They don't work, but that is another story.)

The controller can construct an order to solve the problems of this aircraft. (In the demonstrator DEMFAST, available with David (1997), keystrokes are used because the software available does not support a mouse, although a mouse would be preferable.) As the order is constructed, the trajectory is revised, so that the consequences of each maneu-

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ver can be seen. Figure 8 shows the trajectory constructed when the controller instructs the aircraft to descend to FL310 (31,000 feet), and stay there until four minutes from now. (The aircraft itself and its three partners in crime are no longer visible, since, if the order is accepted, they are no longer involved in conflicts.) The system assumes that the aircraft should return to track after the problems have been solved, and calculates the necessary changes in heading, flight level and speed to get it exactly back on track at exit. (If it can't do so, the last track segment turns red.) The controller develops a satisfactory series of orders, which is checked step-by-step as is it is built, then accepts it. The system transmits the order sequence by datalink to the Flight Management System of the aircraft. The message would be spoken to the controller and to the pilot and copilot of the aircraft addressed (and of any other aircraft in the vicinity) by voice synthesizers in the language of their choice, eliminating the classic Zagreb problem (Weston and Hurst 1982). (At Zagreb, British and Yugoslav airliners collided in midair. The controller gave instructions to the Yugoslav airliner in Croat, so that the British airliner did not know that it was climbing to the same level.) The controller has already turned his attention to the next problem without needing to verify the correct reception of the order, or to remember to return the aircraft to track later. (The traditional voice link would be retained for special messages and "social communications." Pilots like to know that someone is aware of them, and controllers like to know that someone is awake in the cockpit.)

After a little practice, this system is considerably faster than spoken control. A noncontroller can handle the demonstrator's limit of 40 aircraft simultaneously, where each aircraft remains in the airspace for 12 minutes, corresponding to an entry rate of 200 aircraft per hour, at twice real-time rate.

In a real system, this demonstrator would be expanded to include methods of monitoring deviations from track, or learning more about the aircraft. Controllers would learn to recognize particular "hot-spots" in the traffic, and anticipate problems, as they do in the existing system. Additional displays might be designed to help the controllers cope with "foreseeable emergencies," such as emergency decompression or engine failure, where one controller would take charge of the aircraft in difficulties, while his partner would supervise the rerouting of other aircraft.

Overload Backup

Although controllers enjoy, and are good at, solving conflicts, there may be occasions where a temporary overload means they cannot solve all the problems in time. There should be a process triggered by the equivalent of a "short-term conflict alert" to ensure safety if

Figure 6
Seven conflicts (spot the most urgent)

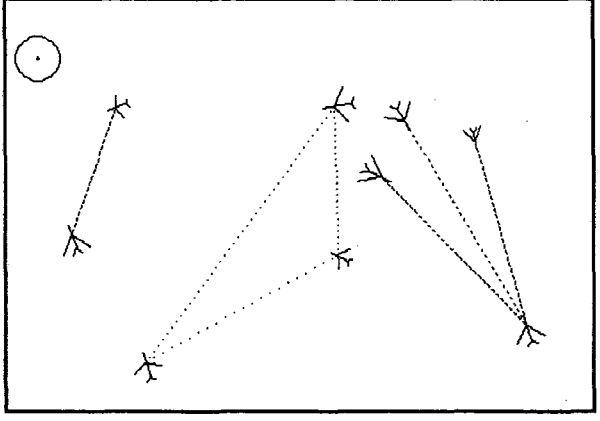

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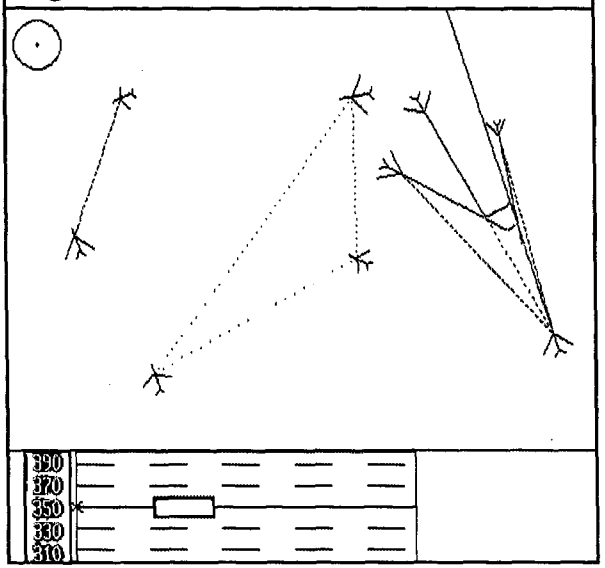
Figure 7



potential conflicts are not solved within a safety limit. The Airborne Conflict Avoidance System is such a system. The backup system should be essentially safe, while not as efficient as the human controller. Given the nature of human beings, the temptation to rely on the backup system should not be offered.

Underload Backup

Underload is as much of a problem as overload. It is not humanly possible to remain alert for long periods while doing nothing. The system would increase the minimum separation, or draw attention to sub-optimal flight paths when no potential conflicts were in sight. Additional work must have some real benefit. Controllers are not stupid, and "make-work" tasks would be quickly seen through.

Organizational Repercussions

The alternative display system designed here is not simply a cosmetic redesign of the existing system. It produces a considerable increase in capacity, reducing the number of sectors, which itself reduces the amount of coordination involved. It reduces the mental workload of the controller at the cost of his ability to maintain a continuous "picture" of the present and future traffic. (He probably could not maintain a picture of this amount of traffic in direct flight in any case.) The traditional distinction between the Planner and the Executive disappears. (In real-life ATC practice, the "official" distinction between these two roles is already considerably blurred.) The "style" of control changes from a continuous "hands-on" style to a "control by exception," where the controller must react to the (future) problems detected by the system, and the immediate problems presented by emergencies. This would have considerable implications for initial and continued training. There are very good reasons not to reduce the control team to one man, as there are not to reduce aircrew. (Yerkes Law—"One chimpanzee is not a chimpanzee at all" [Yerkes 1945] also applies to controllers) There will still be a pair of controllers, but each will be capable of all the control tasks, just as the modern airliner has a "pilot flying" and a "pilot not flying." Training would include drills for the allocation of tasks between operators (and the system), as with Cockpit Resource Management training in civil aviation. Control centers would include built-in simulators, in which controllers would carry out weekly refresher training.

Conclusion

The current Air Traffic Control system

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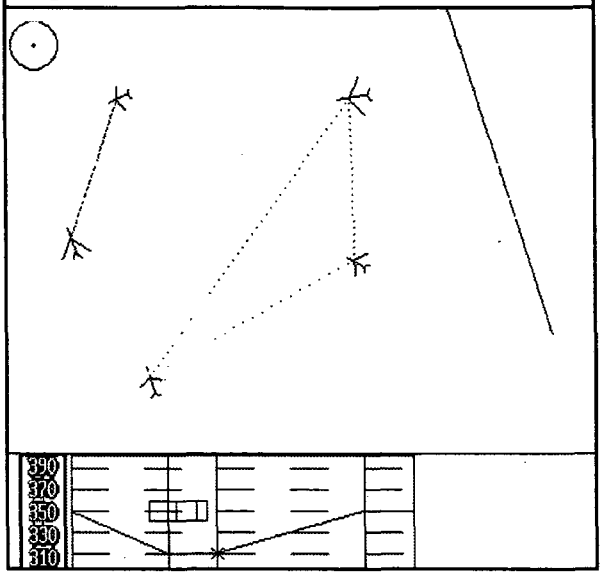
has reached the end of its life. A better system can be provided that will be cheaper and more effective. This requires the transfer of most routine work from the human controller to the computer system. It also implies that the computer system should be trusted to do things that the human controller does at present. Although this implies a revolution, rather than what is called "evolution," it is largely a revolution of methods and attitudes. All the physical equipment already exists, and only the political will is needed. □

Figure 8



ABOUT THE AUTHOR: Hugh David is an ergonomist, working as (the only) Independent Research Fellow at the Eurocontrol Experimental Centre near Paris, France. (Eurocontrol is the European Organization for the Safety of Air Navigation, an international organization of 28 European countries, primarily concerned with improving air traffic control in Europe.) He discovered Analog *(as* Astounding*) in 1951, showed a copy to his science teacher, and received four strokes of a cane in return. He wrote his first computer program (for a valve machine) in 1958 and designed his first human-computer interface in 1961. He began studying air traffic controllers in 1963, receiving a Ph.D. from Loughborough University in 1970 for a thesis on the ability of controllers to judge potential conflicts on radar (which he now considers completely mistaken) and has been studying controllers ever since. The ideas expressed in this article are his own, not official Eurocontrol policy.*

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[2] This report includes a 3.5" disc with compiled code, source code and documentation for demonstrations of traditional, intermediate and fast interfaces. Copies are available on request from dav@eurocontrol.fr or Dr. H. David, Eurocontrol Experimental Centre, BP15 Bretigny-sur-Orge, 91222 France CEDEX.

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IN TIMES TO COME

Our next issue, as we hinted last month, marks two special occasions, and we'll celebrate with extra pages and lots of special features. January 2000 marks the beginning of a new millennium (at least for that sizable segment of the population that starts counting with years ending in "000"!), and the Seventieth Anniversary (for everybody!) of this magazine (which has, so far, spent thirty years as *Astounding* and forty as *Analog*).

We'll start off with a dramatic cover by Kelly Freas, often called the "Dean of Science Fiction Illustrators" and one of the most prolific and popular artists in *Analog*'s history. This one illustrates "Under," a new novella by Hal Clement, often called the "Dean of Hard Science Fiction Writers." Mesklin, the supermassive, fast-spinning planet on which effective gravity ranges from a few Earth gravities at the equator to several hundred at the poles, first appeared in *Mission of Gravity*, serialized here in 1953, and still regarded as a classic of science-fictional world-building. Now, decades later, Clement returns to subject the Mesklinites to a new kind of peril. . . .

Jack Williamson, the only living writer associated with *Astounding/Analog* in every decade of its history, offers a personal reminiscence about his career and ours, and Mike Resnick offers a whimsical look at one of the ways our field has changed in that time. We'll also have a wide range of stories by such writers as Michael A. Burstein (one of the newest winners of the John W. Campbell Award for Best New Writer), Ben Bova (who is not only a frequent contributor, but served admirably as *Analog*'s editor in the 1970s), Larry Niven, and David Brin.

Brin's story, by the way, is a *tour de force* that might in a sense have been inspired by another *Analog* writer. In his 1986 serial *Marooned in Real Time*, Vernor Vinge introduced the concept of "The Singularity," a point in history at which the curves of progress become so steep that essentially everything changes radically in practically no time. The idea quickly became widely known by that name, and David Brin's story in our next issue takes a dazzling look at a world *beyond* The Singularity.
All in all, we think it's a very special issue, offering a sweeping look back at our past and ahead to our future!

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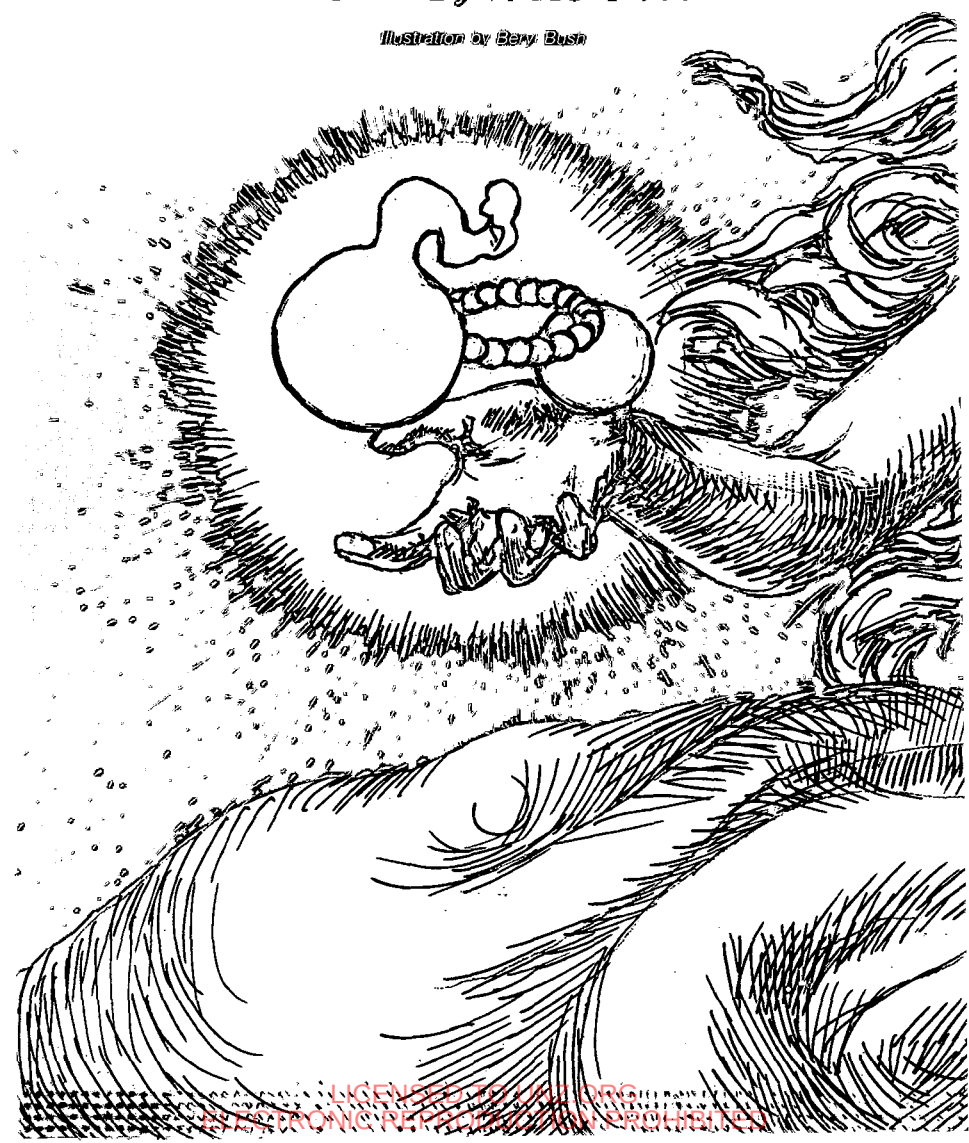
Diane Turnshek

DANCING IN THE LIGHT

Extraordinary problems demand extraordinary solutions. . . .

Illustration by Bery Bush



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The need for beauty is as positive a natural impulsion as the need for food
—Luther Burbank

I was in deep space studying the physical properties of active galactic nuclei when the astral projector appeared at my elbow. Regardless of how many times it had happened in the past, it still startled me. Instinctively, my arms flew up to shield my face, arms as insubstantial as his. I was angry that he surprised me and even angrier that he was bothering me while I was working. I craved the isolation my research provided, a hundred million parsecs from Earth with all its petty interruptions and minor emergencies. Turning away from his shimmering form, I made him wait. He couldn't deliver his message until I looked directly at him.

The unmoving galaxy before me was in its infancy after a bungled breech birth. The galactic core was too hot and dense to support normal stellar activity. Enormous explosions had ripped through the galaxy. Glowing gases and dust were caught in freeze-frame, churning out from the center as if trying to escape the next blast. In the wake of the bow shock, straight garden rows of new stars were sown.

I started again as the messenger appeared in front of me, his image outshining my galaxy. Before I could react, he began to signal to me in American Sign Language, the only way members of the astralnaut corps could communicate while we were non-corporeal.

He didn't begin with "Mr. Quinn" or my Corpmaster title, but with an exaggerated gesture, "#Please, let me talk#"

I recognized him now, although his name slipped my mind. He was one of the first astral projectors. I noticed that he took quite a few liberties with the reproduction of his physical image; his face was a little too handsome, his muscles larger-than-life. At least he was not as flamboyant in his changes as two-faced Jeena Ashe who portrayed herself as the most devastatingly beautiful woman in the known universe.

With my own image, I've practiced enough to achieve millimeter accuracy: a face, rugged, creased and worn after only three decades, and a runner's body, gaunt not from exercise, but from living a life without peace. Since the astralnauts first went into public service five years ago, we have all visibly aged.

He repeated himself to get my full attention, then signed, "#Emergency (!)#Sun F-L-A-R-E#Earth, light hits#eight minutes future#" and motioned me to follow him.

Interrupting my reverie was not a thing I forgave lightly, especially if this was a false emergency. Instead of using the wonderful old Italian hand motion that came to mind, I laboriously signed in response, fingerspelling the words with no ASL equivalents.

"#Danger to Earth (?) electrons, protons, C-H-A-R-G-E-D particles hit Earth (?)#"

His right fist nodded up and down mimicking his nodding head. I continued. "#No#light, eight minutes, but ions, hour-hour-hour#"

The puzzled expression on his face made me wince, for I had seen it so many times on the faces of my students. There was no way I was going to try to explain how the energy distribution from the Sun would be altered only slightly, and would not appreciably change the Earth's biosphere. Perhaps some poor sunbathing suckers would need Skin-So-New. With a large enough flare, the Southern Hemisphere would see a magnificent display of southern lights as some of the charged particles spiraled down the magnetic field lines to the geomagnetic South Pole. The slim possibility of real danger was something I could only determine in person, so at the messenger's insistence, I agreed to follow him. I was wondering how I could capture this aurora australis on tape when I popped into solar space.

The solar flare was enormous, easily

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ten times as large as the most disruptive flare on record. We had come out near the Sun's north pole to verify the alignment with Earth. From this vantage point, the Sun's surface looked deformed, a round yeast mold budding. But the "bud" was much larger than the Earth. I'm always frustrated by the desire to vocalize while astral-projecting, but this time the stream of livid curses bubbling up through my consciousness with no outlet was threatening to tear me apart. I silently damned myself for being stubborn, wishing I could have back the precious minute I had just wasted. Numbed, I stared at the fiery finger reaching out toward Earth, while the scientist in me assessed, surveyed, calculated.

Nearby, the bright, spherical shapes of initiates on a field trip clustered around a teacher, the lovelier-than-truth form of Jeena, and about a dozen other glowers, most of whom I had met at the Academy in living flesh over the past few years. And, as always, scouts were hanging around, lookouts, whose duties were ostensibly not military, but who answered directly to the Secretary of the Exterior. They all bobbed over to me, waiting for me to handtalk. I felt so unlike them. Mystics! How could they be part of the astralcorp and still believe all that hocus-pocus about projecting being tied to unmeasurable quantities like state of goodness or religious conviction? Was I the only one with a scientific background? Never had I felt my differences so acutely.

"#Emergency-Top (!), Class 1#tell to T V broadcast place-place-place#warn people stay inside must#astral projectors find all#return fast#"

The nouveau-sign for astral projectors, fingers signing the letter R flying off the forehead like a rocket, usually brought a smile to my face, but this time the fright-face fit my mood. Around me, lights winked out.

Jeena stayed behind. The most startlingly beautiful collection of charged particles that ever was moved near me, her face searching mine for answers that weren't there. Forced to appear completely in white, like all astralnauts, she alone didn't look older for it. Platinum blond hair flowed about her shoulders. Instead of holding a steady image, she let her soft Grecian gown and long hair blow in the solar wind.

Steiner's misquote of Goldsmith echoed in my mind: "Beauty is as beauty moves;" and I cursed whatever strange compulsion had made me memorize an entire chapter of Steiner's "Quotes and Unquotes."

She continued to float towards me, right into my personal sphere, which makes it damn inconvenient to use sign language. Instinctively, my chest swelled, and some of my scintillating particles redistributed themselves to her two closest points. She acted like she didn't notice, but she must have; one of the first mental skills in creating a spectral body is learning to be aware of the presence of charged particles. Either she was intentionally flirting with me or the flare scare had totally overwhelmed her. Not for the first time, I wished I had met her in person just once. Her appearance must be a work of art, not a true representation of her face and form. I had to remind myself that my real body was lying on a pallet in an undisclosed safehouse, carefully monitored by my own staff. In my insubstantial form, I dared not reach out to her and hold her against me as I ached to do. But I couldn't help feeling flushed with desire.

She signed gracefully, as if she were born to it. Palms out, she pushed her hands toward the Sun. "#Afraid#me-help-you (?)#"

I backed off a pace, dismissing her curtly. "#Orders follow (!)#help-me#go now#"

In a most disconcerting manner, she first turned away, then vanished, leaving me with the lingering afterimage of her remarkable backside. Her projected perfection drove me crazy, but I resolved not to let thoughts of her distract me.

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Solar physics is at the other end of the spectrum from extragalactic, my own personal area of expertise, but I knew some of what would happen next. The Earth's upper atmosphere was already swelling as it absorbed the initial onslaught of X-ray and extreme UV radiation. The new atmospheric drag on all low-altitude satellites would bring them down as harbingers of the changes to come. In a few short hours, the magnetic field protecting Earth would ripple and tear as protons and electrons accelerated by the solar wind bombarded it. If the ozone layer were seriously damaged, Earth's biosphere could start an irreversible transformation. I hated the direction my thoughts were going. Images came to me of bare trees standing tall in silent forests and of oceans brown with the floating scum of decaying sea life. I couldn't let it come to that.

Opening my mental floodgates to all ideas, no matter how far-fetched, I began searching for the idea that would save Earth. The Moon wouldn't be in a position to help; no solar eclipses, total, partial or annular, were scheduled for the next few days. The U.S.S. Sailfin could unfurl her gossamer magsails in an attempt to obstruct the fiery torrent from the Sun with as much success as a naval schooner sacrificing her sails to the fury of a tropical storm. It would have been a real coincidence, and not particularly useful, had Mercury or Venus been scheduled for solar transit, but I checked anyway. When I ran out of ideas for a complete solution, my thoughts shifted towards partial solutions.

I am not a quitter, but the flood of ideas slowed to a trickle, a drip, and then stopped entirely. As idea after idea was rejected, my tension mounted. When the well ran dry, I floundered in space, staring at humankind's destiny in the form of a huge, fiery solar eruption.

I turned towards Earth. The United States would be bathed in daylight now. I thought of the small town where my body was lying; the town I had grown up in. I had been able to project for as far back as I could remember. Throughout my childhood, I had kept my nocturnal astral travels a closely guarded secret. Mental wall-building kept me sane, fortified each time I saw the seedier side of humanity. Voyeurism is present in us all; without the restraint that comes with maturity, I saw more than any child could possibly understand.

I got my doctorate in astrophysics at a very early age. After the astralcorp was formed, it became obvious to everyone how I had accomplished it. I had prepared my observing proposals to the South African Large Telescope carefully to prove my radical theories of the physical properties of galaxies. I knew in advance where to look to prove each unusual hypothesis because I had already traveled to the proposed sites. I could use a radical theory right about now.

I circled the Sun, hoping for inspiration. Why did I feel as though I was the only one responsible for finding a solution to this crisis? Was it because I was the Corps's only astronomer or because I knew no other research scientist was in the privileged position I was, able to transfer my thoughts instantaneously to wherever a solution might be found? Too bad there weren't more projectors. Jeena does more than anyone to find others who are capable of traveling the astral plane.

Jeena again! With the whole world counting on me and the minutes counting down, why couldn't I push thoughts of her out of my head? I pictured her at her very best during her "Dance of the Planets" gigs. Her dance troupe puts on free astralnaut recruiting concerts around the world culminating in a nighttime aerial ballet above hundreds of thousands of upturned faces. With the fervor of Baptists at a revival meeting, her minions implore newcomers to join in the dance. The cadence of slow Greek *sirto* or *zembeqiko* mesmerizes the crowd. Not many concertgoers real-

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ize that the dance troupe cannot hear the music in their out-of-body state, but rely on the strobe lightshow to mark the beat.

Standard mass hypnosis techniques are used under the guise of entertainment. In the dark, a warm, disembodied voice drones on about the techniques of separating the mind from the body, accumulating and shaping charged particles and translocating. I know it's taped; I like to imagine it's Jeena's voice. Times have changed—now the majority good-naturedly tolerate this part as one would an after-dinner speaker at a business conference. Perhaps it has to do with the large family stipends projectors get from the Ubiquitous Council. In the hushed, darkened stadium, the astralcorp ranks swell, one pinpoint of light at a time. Then comes the thunderous finale; the crowd stomping wildly, the scintillating dancers in a ring circling faster and faster to create a magnetic field that draws the astral spirits of the neophytes upwards. After a final explosion of spectral fireworks, the new recruits are ready to be sworn in.

The mind works in mysterious ways. An idea for Earth's salvation crept in while the dancers whirled in my head. An idea so bizarre that under normal circumstances, I would hesitate to voice it.

I made a reconnaissance flyby of the prominence, skirting its edges, noting how it had swelled even in the few minutes I had been studying it. For years, superflares have occurred on solar-type stars, stars like S Fornacis, 5 Serpentis and MT Tauri. The danger of our own placid star turning monstrous was so low it was below the level of logical probability. Yet, the level of solar magnetic disturbances has increased incredibly since 1900. People were used to occasional power outages, disturbance in short wave radio communication, and sometimes an overload in telephone circuits.

This flare was extreme. I couldn't help thinking of the cosmonauts who were about to get a potentially lethal dose of radiation. My idea was unverifiable; I hoped I had enough authority to command the astralcorp on a mad hunch. Like all crazy ideas, this one counted on speed and a certain measure of secrecy.

The messenger was the first to return, just as I finished calculating angles and fixing positional markers. I set glowing balls made up of charged particles in a large ring between the Earth and the Sun, but they wouldn't last for long. Timing would be critical.

"#Boss#" He paused and composed himself, literally, then his arm flew in an arc mimicking the dome on the Ubiquitous Council Chamber. "#All astralnauts reassign#emergency, messages, carry will#"

I could see him quake at my horn-mad face. We were more than just message carriers. My secret plan was dashed before I'd even had a chance to tell anyone. Frustration at the stupidity of the Ubiquitous Council boiled up in me. They wanted so much to have control over projectors. The world's populace had been terrified of us five years ago when we had first come out of the closet (in some cases, quite literally). We had given up our freedom to the newly formed Ubiquitous Council to assuage the fears of all the varied people of the world. But this was not a political problem and it could not be solved by discussion. Selection effects demand that the people who make it to power love to hear their own voices. If they wanted a chat with me, they'd get that and more. Boldness would have to replace secrecy. With the Sun's seething hydrogen/helium horror mirroring my own inner turmoil, I jumped.

The Council Chamber was about as cozy as a sports arena, and just as bright. The councilors were standing in small groups, talking amicably. From my vantage point in the dome, I cooled down enough to decide angry theatrics was the most strategic course to follow. I simply did not have time to explain all the details of my half-baked plan to this

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gaggle of groundlings. My heart was pounding for a showdown.

An upper limit has never been found for how many charged particles we can gather to our spirit, as long as enough particles are available and we don't ignore the bounds of electrostatic repulsion. I had to condense myself nearly solid before I could be seen; that ought to make their hair stand on end. For effect, I decided to appear larger than life, feet spread and arms akimbo. I bounced monochromatic fireworks off the ceiling to get their attention. Would that I could have boomed out in an echo-ringing voice to complete the God-portrayal, but instead I had to sign and be interpreted in a plethora of languages. It wasn't only the Americans who had refused to learn a new language this time.

"#People mine#release#for me#"

The English translator's cherry lips framed, "Let my people go."

The Secretary of the Exterior stood and looked up at me. "Corpmaster Quinn, why? What is the situation, as you see it, at the Sun?"

The translator was still signing, oblivious to the fact that I had lip-read and was already responding. "#Situation critical#time waste can't speak now#astralnauts tell all#meet at Sun's checkpoint#"

Since learning ASL, my understanding of body language had improved vastly. I could tell the answer would be "No" preceded by a lot of hedging. I was challenging their authority on their home turf and in front of witnesses. Witnesses? The Press! One glance at the balcony with its multitude of animal and mineral eyes staring back at me was enough for me to decide my next move. Secrecy or boldness should have worked, but hadn't; now it was time to try cleverness. At the first positive-sounding statement I would cut out. I knew that a politician could never resist beginning with a compliment.

"Mr. Quinn, we all understand how you feel. . . ."

That was all I needed. Before the word "but" hit the air I had signaled, "#Thank you, Secretary#" and bowed out.

Sometimes, I travel faster than my thoughts. An important minute of time was wasted as I jumped from one major network ready room to the next, repeating my message. The footage taken of me confronting the Ubiquitous Council had much more network appeal than that taken against the drab, navy background of the ready rooms. It took me a minute to realize I was stalling. Projectors wouldn't be sitting at home watching the news, even if their vids still had electrical power. There was only one way to reach a significant portion of the astralcorp quickly. I jumped.

From three hundred feet up the treetops merged to resemble a wrinkled, green blanket on an unmade bed. What looked like a one-lane dirt road ran along the trough between Tennessee rills. Nothing in this idyllic scene hinted at the vast network of natural caverns housing the Department of the Exterior's secret astral spy network. Five years ago, they had made me a job offer, which I turned down faster than a flick.

I took one quick flick now to verify that not a soul was at the Sun's North Station. I guess the Council had chosen not to cooperate. My last thought before entering the spy caverns was to wish that I had paid more heed to the muttered whispers of weapons against glowers.

The gray monitor room had one ugly difference since I'd been there for their job interview: the seated operators were armed with backpacks and weapons that any children's toy manufacturer would have been thrilled to copy. Consoles showing the current positions of the seven hundred astralnauts took up an entire wall. Alarms I couldn't hear must have been jangling all over the complex the instant I arrived. Three men surged towards me, leveling their feeds. Leaving a faint spherical image be-

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hind, I jumped across the room, scanned the maps on the upper level, and then appeared as two concentrated points of light under one of the operator's metal stools. The weapons discharged and dissipated my scant afterimage. Immediately, a pulsating blue light showered the room. Although the suited operators were walking around in it, I had no doubt that if I left my protective cover I'd be in serious trouble. Would I find myself back in my safe-house awake with a slamming headache or, more likely, the link to my body broken? I had always thought this was the way I would die, drifting loose until I dispersed completely. I felt like screaming, "Not now!" but vocalizing wasn't possible. Whiskers and a tail began to glow faintly around me, a manifestation of my trapped-rat mood.

The security team ran the film of the attack repeatedly to determine my motive, trajectory and probable return pattern. Considering the high stakes, it wasn't important that my identity be secure, but I had chosen minimum exposure; the film would show only a pair of glowing eyes sweeping over the consoles. I couldn't have shown less; I needed to form some sort of visual receptors in order to see.

Only the lower left corner of the bank of monitors was visible from my vantage point and, scanning it, I noticed that one astral projector was here in the caverns, not two rooms away. Like a rat smelling a trap, I strained to see who it was. Of course! What more perfect bait than the lovely Jeena?

Or was I being paranoid? I knew of her recruiting work, but that couldn't take up all her time. I was painfully aware of each and every time her image had crossed mine in the past five years. Outside of the school, I had always found it easy to avoid her; perhaps the reason why lay here at the spy caverns. The DoEX used only a couple dozen astral projectors to keep track of the rest of us. Jeena would certainly make an ideal Mata Hari. At the Sun, her eloquent offer of help had seemed genuine; perhaps I could convince her that I had the Ubiquitous Council's approval for my plan.

It was the first time I had needed to trust someone or ask for help. Yet, to take a chance with my life was to put the Earth's survival in jeopardy.

After an eternity of forced internal reflection, the blue light switched off. I hadn't taken my rat's eyes off the monitor showing Jeena's location, and, when she began to shift position, my decision was made. You can't move a trap, and if I lost her I'd lose my opportunity to ask for help.

Jeena had jumped to a room deep in the caverns and I went in after her. She stood poised before the light terminal in a primary command center. The words, "A form so fair, that, like the air, / 'Tis less of earth than heaven," were written hundreds of years ago—how could they fit Jeena so flawlessly? I couldn't help wondering why she clung to her illusion of beauty even when she was alone.

When she saw me she beamed and nearly threw her arms about me before catching herself. She signed that she had searched the world over for me and seemed genuinely happy to see me, but not surprised that I had known where to look. I had to smile back. She glanced behind her at the blinking terminal, and then back at me; her cheerful face dropping like a mime's into a scowl. With one wave of her arm in front of the light terminal, a half-dozen astral projectors appeared at her side. She named me "the intruder" and insisted that I identify myself.

Bristling at the waste of precious seconds, I flashed through an identification sequence I had set up not a month before. Why was she suddenly suspicious of my identity? At computer confirmation she turned to me, all business.

"#Solution for crisis have finish (?)#"

"#Yes#all nauts need now—#"

"#—at North Solar Outpost#" she ended my sentence for me. Studying my

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face, she nodded. "#Can do#" she signed and then turned to the light terminal once more. The air suddenly shimmered around us as the room filled with a dozen more astral bodies. So these were the military scouts that kept track of us civilians, and they were looking to her for direction. Interesting . . .

I watched her instruct them to quickly find all astralnauts and meet us at the Sun's primary checkpoint with no questions asked; it was like seeing a glittering diamond-dust work of art in graceful motion. I was assured they would stand ready to repeat my instructions to the crowd.

Their shimmering ceased and the two of us were alone again. Her beauty and nearness tugged my mind off its track.

We both began to sign simultaneously. With eyebrows down, I asked, "#Who are you (?)#"

"#Sorry#" She looked truly embarrassed.

I moved my image over to a chair, not because it was a lower energy state, but as a formalism to give her the floor. Her suddenly contrite demeanor contrasted sharply to the professional poise she had assumed when speaking to the astralnauts.

"#Sorry#Me think false you#really Quinn me not sure me#" She signed without looking at me. She had every right to ask any intruder to run through the identification sequence. Her apology didn't make sense.

"#Smile yours#" She looked at me, the word "smile" lingering on her face.

I guess it was catching, because I gave her what I guess was only the second smile she had ever seen on my face. I couldn't tear my eyes away from hers, but my peripheral vision was enough to watch what she was saying. I could hardly believe the faith she had in me. She had thrown in with me and there was no going back. She had exceeded her DoEX authority—we were in this together now. Sick of being abused as superspies, the DoEX projectors were tired of legislative manipulation with no vision, and they were ripe for a change.

She was signing so fast, I missed some of what she was saying, but her disgust was plain on her face and in her body language when she mentioned bathroom duty at the Pentagon. As much as I knew we should leave, I had to give her another precious minute.

"#Revolution organized not#secretly meet home my Tugela Falls, but what to do(?)#surprised-emphasized you U-everywhere Council say no to#proud#"

I wanted to ask her a million questions, but there would be time to talk later. Or there wouldn't. Suddenly, it was very important to have something to look forward to after our battle with the Sun. I felt I owed her something for her support, but what?

#Everything finish, then#trip see aurora (?)#you join me (?)#

At first, I didn't think she understood me; my signing is so clumsy compared to her fluid motions. She stood still for a moment, then burst into activity. I guess she accepted my invitation to go see the aurora, if a double pirouette and a low curtsy meant "yes." She stood, proffered her hand and signed that we should be going.

I wanted to reach out to her, but I couldn't make myself do it. I knew we wouldn't have the sensation of touching. Her outstretched hand made me shudder; I hoped it wasn't obvious.

Non-corporeal Merging 101 was a required course at the Academy. The memory of failed classroom experiments chilled me. My instructors' voices, "Relax, Quinn . . . Open your mind to your partner . . . Togetherness is divine," blurred my vision. Hypothetically, it was possible to speak directly to each other's minds while merged, but in the tests I had heard of, it created an imbalance, almost an addiction, to continue contact. Non-CM 101 was the only course I flunked repeatedly until my teachers gave up and passed me out of their sight. When Jeena offered her slender

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arm to me, I jumped 150,000,000 kilometers away.

At the North Solar Outpost, all was awash with light from the Sun, the flare and the glowers encircling me. All different skill levels were manifest. My gaze swept over the non-segregated crowd, taking in the scattered sequence of figures from globes through lollipops, stick figures, paper dolls, gumbies, puppets and marionettes to the artistry of the woman at my side.

Dressed totally in white, they reminded me of the partygoers at a vernal equinox, rites-of-spring costume ball I attended as a youth. That night, I had covered my nervousness by pretending the white revelers were the projecting friends I never had. The hostess never forgave me for crying in my white wine.

Jeena flung her arm out. Her crew spread through the crowd following orders like a queen's royal guard. I scanned the familiar faces as they distributed themselves in front of me, blocking my view of the solar disturbance. My hands moved of their own volition; hooked right index finger over left, then left over right, and again.

"#Friends#" I paused, surprised at myself for starting in that way. "#Energy reserves check must#now#"

The view of the scintillating glowers was cut short as I leapt home. It's a good thing I have my own power source, because lights were out on all sides of my safe-house. My estimated energy reserve meter stood at forty-seven percent. That wasn't good. I had been out doing research for many hours before the crisis struck. I bumped the safety down a few notches then opted to spend a fraction of a second looking in on Grove Widmer, who takes care of me while I'm away. He was watching a foolhardy astralnaut on the news facing off against the Ubiquitous Council. I didn't disturb him, but leapt back.

The others were still arriving. Did they all feel the same reluctance to leave home that I did? Even Sparky, the little kid who could only form the image of his collie, looked subdued, his tail motionless for the first time since I'd known him.

It was hard not to start with a description of how filaments fill up with solar plasma then snap like stretched rubber. At the University, my lecture would have mentioned the cloud of particles with a diameter of thirty million miles, heading for Earth at a million miles an hour. Looking at their fearful faces, I tried to make my gestures look strong and confident.

"#Need form ring#Magnetic field create turn C-H-A-R-G-E-D particle stream away from Earth#"

My kingdom for a blackboard! They weren't getting it. I tried again. I started with a slightly bent five-hand classifier to signify the ring, then pointed to the location in space where we needed to form it.

"#Same-same newcomer's dance#you-all many I-O-N-S gather-in#Earth-Sun line spinning-ring tipped#"

I looked at the blank faces of the artsies around me and knew I was in trouble. What good was knowing the magnetohydrodynamics of coronal mass ejections, if I couldn't explain it when I needed to? At my side, Jeena extended her hand. A shining sphere coalesced in her upraised palm. From its side, an angry finger pointed towards a second, smaller point of light. Reaching, reaching it was suddenly turned aside by a whirling bracelet of pearls. I saw the light dawn on their sunbright faces. I guess there's a place in our world for artsies after all.

"#Thank you#beautiful#" I looked at Jeena and wondered why I used the sign for "beautiful" instead of the one for "accurate." I noted that the inclination was wrong, then waited while Jeena's crew repeated my words for those who were not in a good position to see me. Those under fifty-percent energy reserves I sent home to pump up till they hit ninety percent, since we would be in the

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ring for at least a day. I didn't want anyone losing their link. Only a few blinked out. After pumping up to ninety percent, there is usually a long stretch of diminishing returns; I hadn't bothered to hit a hundred percent in years. I was hoping I wouldn't be hitting zero today, as my nervous group moved closer to Earth, directly in the path of the solar ejection. The glowing, positional markers I had placed were gone, swept before the storm. Instead of replacing them, we began. Everyone joined hands like square dancers in a circle, but, as the caller, I held back.

Simultaneously concentrating on acquiring mass, moving back from the center and starting a slow spin was more than a few could handle. I plucked them out of the line quickly, so the momentum of the others wouldn't be compromised. I sent some of these "dancers with two left feet" to research scientists whose work I respected. It wouldn't hurt to have my most important calculation refereed. More went to testing facilities spaced around the world to check our progress. One went to the press and six spread out from the ring's center up and down the x, y and z axes to monitor the alignment of the spinning band with respect to the Earth-Sun line.

The circle of dancers was expanding slowly, but, instead of following the law of conservation of angular momentum, they were visibly gaining speed. I flitted back and forth across the ring, encouraging, ordering, cajoling, doing everything short of physically pushing to keep the formation tight. I matched velocities with a gumby who was out of step. Since we were in the same frame of reference, no nearby motion was visible except our signing.

"#Pace keep up#"

His form was drawn in thick strokes; he barely had enough finesse to sign intelligibly. He freed his hands to communicate with me.

"#Can't#scared#flare hits killed-killed-killed#"

"#No#flare here now#can't see#live will you#pace keep up#"

Everyone always seemed to know where Jeena was located in a group. Perhaps it was the fireworks she was so fond of shooting off. It was logical to set up my temporary headquarters in front of her. She had chosen to stay life-sized and had amassed the particles she was dragging through space into a huge, flat wall stretching left and right to her partner and her corner. It was there, hurtling through space, that we received a smattering of disjointed messages from the planet. Ozone layer monitors reported no significant changes yet. The press was making a massive effort to inform people on the daylight side to stay indoors, but they were hampered by scattered power outages. The Secretary of DoEX had called me the first planetary traitor in front of reporters. Entrepreneurs had begun production of millions of lead-lined umbrellas.

Total protection for Earth meant including in our particle sweep the invisible Van Allen Belt with a diameter nearly six times the Earth's. We had agreed that at my signal, everyone would stop the ring's expansion. Gauging visually, I stopped the increase in size to focus my attention on the ring's speed, density and orientation. The first two parameters were within acceptable limits, but when I checked with the alignment spotters along the z-axis, I found the ring precessing like a top. At times, our electromagnetic lens was deflecting the damaging particles in a stream just in front of the Earth in its orbit. Without an immediate correction, the wobble would break the ring apart in just a few moments.

I had to act quickly. The ring's instabilities were non-damping. The time for leading the dancers without joining them was over. This wild idea of mine needed my total involvement to succeed. It was essential that I guide from within, and that meant doing the non-corporeal merge that frightened me most.

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There was no other choice.

It took me a few long moments of terrified thought, and then I set off on my trip around the great wall of light. Blinking on and off saved time, but it put me inside my first target. I was instantly smashed with fear from my host, then tortured with a terror of failing. I tried to broadcast confidence to each scared soul I flowed through, along with the necessary coordinate guidance, but there were too many of them, and their dread too well grounded in reality. Then, they were all gone and I was in a darkened church on a solid wood pew. Parishioners gathered in silent prayer. I couldn't balance my disorientation with the wondrously calm scene in the fraction of a second I was there before plunging back into the whirling maelstrom.

It was preposterous. They were weak and scared and they were FLICKING! I hadn't made it a quarter way around the circle broadcasting my message and supervising the ring's alignment, before I was dragged off to a Euro-family singalong; I couldn't hear the songs, but the gaiety was catching. I flew back to the ring, trying to do my job, then was hauled to a feast in a large smoky chamber filled with torch-wielding dancers. Sometimes, I was in the ring barely long enough to align myself, before the next flick pulled me away. I peeked into a darkened bedroom where several children slept packed together in one big bed. I rode a large, gray horse bareback across a field of wildflowers. I cruised in ocean spray above a coral reef while beneath me clusters of colorful, bright spots turned in time to an unheard beat. Each time, I left the ring only for a brief moment along with the presence of the one on whose flick I rode piggyback.

Each time, I felt the joy spread through me as it spread through my benefactor. It took nearly a complete revolution before I realized I wasn't hitchhiking; I was invited to share the moments!

Then, I sensed Jeena's presence, solid as the mountain she had been dragging along through space. And, as she felt me, she leapt. Without guidance, the mass she had accrued would follow Newton's second law of motion. But at this radius from the center, a straight line would be close enough to the proper curve for a few seconds, anyway. She pulled and I went and then we were standing in knee-deep water in the single most beautiful spot I'd ever seen. Over us towered a kilometer-high waterfall raising rainbow sprays in early dawn light. Surrounding our isolated pool was lush green jungle. Not a scrap of an ion clad her. Morley had said that in every man's heart there is a secret nerve that reverberates to the vibrations of beauty. She signed a welcome to her home and extended her slender arms to me. The vibrations she sent resonated with my sheltering walls and sent them tumbling into the pool.

This time when we returned to the near-solid band, it was my joy that spread. Greeted with echoing jubilation, I threw myself into my comrade's ring, laughing when I heard variations of the same comment repeated endlessly, "He finally noticed her." Each circuit I made got easier, with fewer fears to allay and minimal alignment corrections.

I wanted to share the euphoria I felt. I don't know what prompted me, but I tugged at Jeena as I passed her. Effortlessly, her spirit joined mine in the great circle of light. Our senses mingled. Feelings new to me struggled for attention: peace, hope, love. The two of us were alone in a crowd until she tugged and more astralnauts came loose from their collected particles to swim the ring with us. Onward we flowed, gathering essences to our collective till the ring was void of life beyond our joined mentality. It was like nothing that had ever been done before. I was aware of each individual, but together we were more than the sum of our singular bits. Hundreds of minds, united in purpose,

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surged on for hours controlling the ring and fearlessly doing the theoretically impossible: merging our life forces.

Then the depths of space blackened and perception failed me.

My eyes opened onto a scene of two fuzzy faces, one floating, one fixed. The messenger disappeared as soon as my eyes focused on him; presumably he just wanted to know I had returned. Grove held me down. I tried to sign, "#fine me#" before realizing I could talk. The smell of antiseptic and the painful blaring of a medic alert alarm confirmed that I was in the emergency room of my safe-house. The cold, hard surface below and the firm hands above massaging pain into my stiff, numb limbs was sufficient proof that I had made it back alive. The phone on the wall above me rang once and I heard my prerecorded voice saying, "I'm not exactly here now. Leave a message."

My stomach heaved. Spots danced between my eyes and the background. I had narrowly made it back at all, Grove reminded me, and would need several days to recover my strength. I lay flat for a single, long hour while newscasters waved their hands and talking heads tried to explain 'The Ring' in layman's terms. It needn't be so beautiful to be effective, but it was stunning. A longing built in me to rejoin the others, but to physically move even a centimeter was torment. It would be weeks before I could travel the astral plain again.

Rest, Grove counseled, but I couldn't. In the last hour, my many attempts to find Jeena had failed. I had to be sure she was all right. Locating her safe-house proved to be difficult. Records were easy to falsify, especially for one with her hidden talents.

Doubts about what we had shared assailed me before I even swung my legs off the pallet. Somehow, my pain drove out the elation I had felt in the ring. I wanted to see her in the flesh, but I dreaded finding out how big her lie was.

By letting her reference to Tugela Falls be my lead, I contacted a South African astronomer I knew from my observing runs at the SALT facility near Sutherland. I presented my dilemma straightforwardly, amazed both at my openness and at her ready willingness to help. She called me back shortly with results from a recent satellite site survey of South Africa which showed an old keep on the escarpment above Tugela Falls just outside of the Royal Natal National Park. It wasn't much to go on, but it felt right. Once pointed in a direction, I launched like a spook, unmindful of Grove's pleadings.

Most air carriers lacked sufficient shielding and were still grounded, but the Kuiper VII Airborne Observatory at my disposal was specially designed to block the sensitive instruments on board from a wide spectrum of radiation. I put together a hastily constructed program of solar observations, and then slept right in the observing chair as the pilot took the plane across the Atlantic towards Durban at an elevation of 12,500 meters.

Corporeal travel was irritating to me at the best of times, but now it was pure agony. With each change of conveyance, each downgrade in comfort and speed, my mood darkened. Still nothing was to be heard from any source about Jeena. The ring was dissolving. Hundreds of projectors were missing.

The messenger flashed in and out of existence many times, confirming that the keep I was driving towards was indeed a protected safe-house and adding that records showed it had long been in the hands of a wealthy Dutch family. Prevented from entering by a blue haze, he could not verify that it was Jeena's. At one point, he saved my life by matching velocities in front of my vehicle and reminding me to stay to the left. I found it easy to tell him how grateful I was for his surprise visits. His popping in and out kept me awake during the dragging travel hours, and at last my agitation was

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pulled under control by the haze of nonstop physical motion.

Finally, the ride ended. Gravel crunched under my boots as I hurried up the tree-lined walkway. Loeries and colorful bee-eaters flitted among the stately ash trees with barely a rustle of bright wings or dark leaves. It reminded me of the many quiet hours I had spent bird-shadowing. A calming moment when I needed it most. Like flicking, I thought with surprise and new understanding. The ash trees were obviously imported long ago just for this impressive walk. The new, blue shirt Grove had picked for me chafed my neck in the heat. Looking at the bright, true blue pennants fluttering high atop Jeena's mansion, I was thankful for Grove's good taste in clothes.

The serene walk cleared the befuddlement from my mind and gave me a few moments to reflect. I had made a commitment to a person while knowing nothing about her physically. Was her frame really so important to me? With a start, I realized that she might not even be female. The gray granite steps kept moving closer until they were only a hundred feet ahead.

My resolve was almost gone. I loved Jeena's strength and intelligence, but she had a secretive side. Was I ready to make a commitment to someone I knew so little about? Someone who was capable of haunting me for the rest of my life if scorned? Someone who, for that matter, might not even be human? I could see the twelve-foot oak doors unlatch and begin to open for my, as yet undecided, entrance.

Long dead Virgil's warning crossed the centuries: "Trust not too much to beauty." Like a floodgate once opened, words from the past assailed me. Tolstoy's: "What a strange illusion it is to suppose that beauty is goodness," and Theocritus's: "Beauty is an evil in an ivory setting."

I jumped as the messenger appeared at my elbow.

"#naut here#umbrella yours lead where (?)#"

He had set me up for the standard "Naut here" equals "not here" joke, which doesn't work unless you translate it into English. I couldn't disappoint him.

"#me wish not here me#" With a jolt, I finally remembered his name, Paulo Remington, and his nickname, Mercury.

He picked a location in space to stand for 'Jeena' and pointing to it, signed,

"#Jeena-there#visitors never see never#curtain blue, see (?)#never never#"

Nothing was visible if I looked straight on, but sighting along his outstretched hand, my eyes picked out a faint blue haze surrounding the mansion. The color looked suspiciously like the 4250 Å wavelength of the pulsing light I remembered from the spy headquarters. That meant not even astral runagates had free access to her chambers. So why had the doors opened for me?

Mercury had just arrived from The Ring of Protection, as the newscasters were now calling it. He said the power outages were under control and there was no indication of ozone changes. The press wanted to interview me—but I didn't know how things would be turning out yet, how could I talk to anyone? He hesitated briefly, then mentioned that even as the ring dissipated, most of the astralnauts hadn't returned. The Ubiquitous Council expected a thorough explanation when I felt 'up to it.' I acknowledged that I understood and he vanished leaving me with traces of a good-luck sign hanging in the air.

Though I saw no visible sensors, the doors in front of me finished swinging open, the cold draft hit my face and dissipated my friend's lingering token. I tried unsuccessfully to relax my clenched jaw. Desire warred with common sense. Standing before the doors, I finally admitted my obsession with her and, in naming it, found peace. Whatever I found within that portal I would ac-

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cept, no conditions, no judging. I just hoped she had found her way back to me.

There was no one around and I wondered if this were one of the fully automated recovery chambers recently made available to the spectral community. My bootsteps rang hollowly on the marble floor of the foyer, as if to ignore the sound-damping properties of the two-foot mahogany crown moldings and the hand-woven tapestries on the walls. Richly colored images of gorgeous maidens astride winged beasts and knights braving dangers to win their hands surrounded me. I faltered again when I saw the face on the foremost knight. Why . . . how could it be mine?

The doors at the far end of the foyer took their turn swinging open. Jeena must already be back safely. If she wasn't, why were the doors opening for me? Maybe I was on her computerized auto-entry list . . . if so, my name must have been listed since before this crisis began. Before we shared our souls. It didn't make sense. Answers to my questions lay just beyond the opening, but was it any wonder that I stepped through with trepidation?

My first impression of the huge, nearly empty room was a dizzying sense of déjà vu. Waves of goosebumps raised on my upper arms. In the very center of the room lay a curtained, canopied bed on a raised dais. I blinked hard, knowing I'd never been here before, but the familiarity stayed with me. I suppose it was possible that I had come here accidentally during normal dream sleep and never even realized it. It was a thought that under other circumstances would have my mind whirling with possibilities. Were some déjà vu experiences actually caused by out-of-body travels while in a subconscious state?

Chandeliers hung on long chains from the high ceiling. The myriad of point sources refracted through the crystals lent a diffuse light throughout the room. A separate light source underneath the rose-colored canopy illuminated the bedchamber. Hidden infrared sensors must have indicated I was close enough; the layers of curtains slowly began to part. Through the gauze curtains I saw a still form lying on satin pillows. On their own, my fingers found a parting in the gauze, but I hesitated. The breath caught in my throat. What a dramatic way to introduce oneself!

The figure in the bed stirred, and I hoped that meant Jeena had returned to her body. The light inside the canopy increased in mercilessly small increments. At last, after what seemed like an eternity of standing near her bedside, I beheld her. An unquote formed in my mind.

"She walks in beauty like the light,
That brightens hearts when morning breaks."

Rhyming echoes, knight and aches, fell at the end of each line in the first stanza of my first poem. With not-so-steady hands, I finished pulling the curtain back. The rose-colored silk screening had definitely not been necessary. Jeena looked exactly as she had portrayed herself.

The bedchamber was filled with a sweet scent like camellia blossoms. The bed itself must be the bio-function monitor, read remotely; I saw no signs of panels, blinking lights, heard no clarion of alarms. The mattress was warm and it began pulsating to massage her into wakefulness. I briefly wondered what sitting on the edge would do to the controls, then dropped to her side and picked up her delicate hand to feel for a pulse. I was rewarded by a slow, steady, sleep pulse. I leaned forward to brush a stray golden curl back from her forehead, but found I couldn't resist leaning farther. I thought it was the tenderest kiss a knight ever gave a fair maid. Her lashes trembled and sleepy lids pulled back, exposing eyes as blue as the pennants fluttering over her estate.

She was back!

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She responded to my kiss by taking her first deep breath. I watched her chest rise and fall under the clinging silk sheets. Her ghostly image had attracted me, but that was nothing compared to the way the full force of her presence smote me. She stretched. I've never been thankful for electrostatic cling before. My gaze traveled up and down her body and I clasped my hands behind my back to keep them from doing the same.

"Jeena," I said, my voice husky with emotion. I tried again, lightening it, "Jeena, how do you feel?"

I was sure she felt wonderful. She smiled, her smile irradiating her face. She bobbed her head silently up and down. I was speechless. I tried to catch my breath and my wits. It was all too perfect: her face, her flawless figure, the fairytale atmosphere and the way she looked at me with open approval. I didn't want to start plying her with tough questions right away; some people come home groggy. I was searching for a decent-sounding comment when she squeezed her eyes closed, tears creeping out between the long lashes. Moving her hand to my arm, she motioned that I should perform the massage techniques for emergency resuscitation we all had to learn at the Academy.

Touch her?

My mind balked, but my hands didn't. With trembling fingers, I slid the top sheet down to reveal a pale pink chemise. I began with her icy feet. Her fists knotted up the bed sheets, her back arched slightly and her hips flexed. As much as I tried not to react, I couldn't keep her movements from exciting me; I kept imagining them under different circumstances. By the time I had worked my way up to her thighs, I was panting. Her form was exquisite. Her skin was perfection. Propped on the pillows, she gazed at me with lidded eyes and I faltered. We stared at each other, counting heartbeats. She broke first.

Pointing up she signed, #Roof-top garden there#there two-of-us watch A-U-R-O-R-A upwards there#"

I laughed at her gently. "Jeena, you don't have to sign, now."

I stood dumbstruck as she fumbled, the first ungraceful movements I'd ever seen her make. How could I not have guessed? Did my obsession with the ideal female form blind me to the obvious clues that, with the help of hindsight, were so glaring? Words from Francis Bacon echoed in my mind: "There is no excellent beauty that hath not some strangeness in the proportion." I realized that she was waiting for me to react, but I was having trouble understanding why she had kept it a secret. Sensitivity and tact had never been strong points of mine; I wanted this to work so badly I was paralyzed.

I changed the subject.

"Jeena, what happened to you since I left the ring? Where are all the others?"

She looked at my lips when I spoke.

"#Rest not return#no one left behind#I could not leave you#" she signed.

She came back to me. She came back for me. Did she mean only those astralnauts with someone to come back for would be returning?

"#Many hour-hour-hour#" she signed and tears gathered in her eyes. "#First eat#" Food was about the farthest thing from my mind. She started signing about a trip to Tugela Falls, but I took her fluttering hands in mine to calm them.

I hated releasing them to sign. "#You deaf (?)#Secret why(?)#" I crossed my arms, fists closed, over my heart and assured her that we needed to talk for hours because I understood nothing and wanted to know everything about her. I dared to hope for a chance. In a breath, my obsession with her perfection slid sideways to an unexplored place in my mind; is this where love resides?

Her perfect lips were soft on mine. Touching never felt so good.■

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H.G. Stratmann

TO HIM WHO WAITS

Stuck in an airport?
Read this.
It could be worse. . . .

Illustration by Kelly Freas

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"I'm sorry, sir. Your flight's been delayed again."

R. William Kroosew, Director of the Department of Astrodynamics at the University of New Cleveland on Canopus IV, dropped his suitcases wearily to the floor. "What is it this time?"

The bioid flight attendant behind the counter wore a crisp blue uniform with a gold Pan Galactic Spacelines badge pinned to its lapel. It looked like a buxom young human female with too much scarlet lipstick, and impossibly red hair styled in a cute pageboy hairdo. The only clue to its artificial origin was that "her" mouth didn't move when she spoke, but remained fixed in a toothy smile.

Behind her an electronic display stretched thirty meters upward showing flight information in countless Galactic languages. Kroosew squinted at tiny green letters saying, "Flight No. 13856. Departure Time: 1313 GST. Destination: Omegamons III. Status: DELAYED."

The attendant replied perkily, "Your starship was delayed by an ion storm in the Cirrus system. I'm linked to the spaceport's Primary Artificial Intelligence Network, and will inform you immediately when PAIN notifies me of your flight's new estimated departure time."

Kroosew stroked the back of his head fretfully, then noticed the clump of greasy gray hairs stuck to his palm. His hair had been full and mainly brown when he'd first arrived here. Now he was afraid to look in a mirror.

He grumbled, "We've been through the same thing for a week now. Every day it's another excuse. Yesterday you said the flight was delayed because of a meteor shower near Cumulus VII. The day before that, the starship's FTL drive blew a fuse. And the day before *that*—what was it?"

"An attack by space pirates, sir."

Kroosew's eyes shot up in frustration at the transparent "ceiling" far above them. Thousands of distant gemlike stars shone suspended in solemn splendor against the velvety blackness of space. They sparkled as their light filtered through the force field protecting this huge islandlike spaceport suspended in a lonely void, twenty light-years from the nearest star. A silent, soothing window into the majesty of the cosmos.

Then his gaze returned to the chaos around him. The waiting area stretched to the horizon, bulging with travelers from myriad Galactic Union worlds. A motley mob of sentients and protosentients raucously hooted, whistled, flapped wings, or expelled scents at each other in conversation, while others chased after immature specimens of their kind. A few somehow managed to hibernate, scrunched into one of the seats extending in long parallel rows throughout the area.

But many more were engaged in noisily chewing, sucking, enfolding, or tearing various foodstuffs (some of it still alive), or using portable electronic devices emitting a deafening, eye-straining riot of sound and holo images. Here and there small puffs of smoke rose above the teeming throng, either from small fires primitive sentients were using to cook their food, or the native plants that even less civilized beings were smoking. Nearby, several of his fellow travelers were engaged in violent, limb-ripping, fluid-spurting combat over which of them would claim one of the rare unoccupied seats.

The attendant murmured reassuringly, "Pan Galactic Spacelines, your 'On Time, Some of the Time' spaceline, apologizes for any inconvenience you may be experiencing. I hope the hotel accommodations PAIN arranged for you during these delays have been satisfactory."

"Frankly, I've had more agreeable bedmates than the Denebian slimeweasel you put me up with last night. It kept trying to make a nest for itself by yanking out hairs from a very sensitive, private part of my body!"

The attendant smiled sympathetically. "If it's any consolation, sir, the Denebean

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spoke with me a short time ago. She said she enjoyed your company."

"Well, I didn't! Do you realize how important it is that I get back to Omegamons as soon as possible? I'm the head of a research team there working on a critically important scientific project. We're on the verge of confirming the existence of imaginary matter. If we do, it'll be the most important discovery in recorded history! But I don't suppose you have any idea what I'm talking about."

The bioid stared blankly back at him like a mannequin. *No, I didn't think you did.*

Then her face brightened. "On the contrary, Dr. Kroosew. I just consulted PAIN's exhaustive scientific database. After reading your outstanding textbook on the life cycles of stars, I did a search on the keyword 'imaginary matter.' Summarizing the 19,413 journal citations I reviewed, its existence was first hypothesized by Professor Hzabigolboob of Tau Ceti II in Standard Terrestrial Year 3139. It would have the characteristic of 'variable quantum density'—of changing its elemental composition and increasing its mass in response to psychic energy directed at it by sentients like yourself."

She continued, "As you so eloquently described in your recent article in the *Journal of Imaginary Research*, the primary importance of imaginary matter is that it could be used to modify the ultimate fate of the universe. Current consensus among experts like yourself is that the total density of 'real' matter in the universe is insufficient to halt its continuing expansion since the 'Big Bang.' Approximately one quadrillion terrestrial years from now, the cosmos will contain only the remnants of burned-out stars.

"However, if imaginary matter exists, it may be possible for sentients to 'will' the total amount of matter present in the universe to increase. Given a sufficient amount of mass, and hence gravitational attraction, the universe will stop expanding after billions and billions of years, then begin to contract. Eventually it would collapse in the so-called 'Big Crunch' and, in theory, explode again to form a new universe capable of evolving life."

Kroosew's jaw dropped. "That's—right. My team's been investigating anomalous variations in the mass of Omegamons. The natives of its third planet have religious rituals where they make offerings to their sun, which they consider a deity. When they do, the star's mass increases significantly—as if it were 'responding' to their prayers."

"And an excellent job your team is doing, sir. I found thirty-three citations for papers on imaginary matter listing you as coauthor, second only to Professor Hzabigolboob himself."

"Actually, 'he' turned back to a 'she' last month. Her team is also at Omegamons, competing with ours to be the first to prove imaginary matter exists. Whoever does it first—well, let's just say there's a lot of prestige, grants, and other pleasant things at stake."

The attendant's voice was velvety. "I understand, sir. I'll do everything I can to ensure you reach Omegamons as soon as possible."

She pointed to the glowing red number—"213.39585"—on her PGS badge. "As a Model 38-24-36 Baryonic Intelligence Multiform Biosynthetic Organism, I had a basic expected operational 'life' of 130 terrestrial years at the time of my original synthesis. This badge shows how many years I've been in operation. How much, to use an archaic Terran phrase, 'mileage I have on me.'"

The number changed to "213.39586."

"Uh—excuse me, but aren't you out of warranty?"

"No, sir. Since first coming 'on-line,' I've been extensively modified with self-repairing nanites which keep me operating at peak efficiency at all times. Thus, no matter how long it takes for your starship to come in, I'll still be operating at peak efficiency and able to inform you of its arrival."

Thank you for telling me more than

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I wanted to know. Sighing, Kroosew hoisted his bags back up. "I guess this means another night at a hotel."

"That might not be necessary, sir. PAIN informs me there's a nonzero chance your flight may be ready for departure shortly. If you'd wait in this area for now, I hope to have good news for you soon. Or perhaps you might sample the tasty treats sold at the fine multispecies restaurants in the 4,913 concourses adjoining this gate."

"No thanks, I'll try to find a seat somewhere. My stomach's had enough overpriced junk food lately to last a lifetime. That hot dog I ate three hours ago is still giving me indigestion."

"Did you perhaps purchase it at an eating establishment called 'MakDaizees'?"

Kroosew frowned. "I think so."

"I'm afraid that particular restaurant doesn't cater to the dietary needs of humans, sir. What you consumed was not a 'hot dog' in the conventional definition of a cylindrical membrane containing bovine, porcine, and equine proteins. It was a *xelxa*—a compact colony of coprophagous parasites used by the natives of Lactomagnyzia V as a laxative."

"*Parasites?*"

"Don't be alarmed, sir. The solid waste matter in the human intestinal system lacks certain nutritional elements they require. Fortunately, however, before they starve to death, they'll leave the lining of your colon squeaky clean."

As Kroosew walked queasily away the attendant called after him, "Should you change your mind about having another snack, please avoid restaurants with the 'Megacarnivores Only' sign. The patrons might mistake you for part of the buffet."

There were no empty seats in the waiting area. Kroosew trundled his two suitcases down row after row, futilely searching for somewhere to rest his enervated body.

As his endless quest continued he amused himself by thinking up creative curses and anatomically impossible suggestions for those responsible for his predicament. First and foremost, the Grant Review Committee at the university. They were the ones who wouldn't be satisfied with a standard FTL holo conference call, but had demanded he return to New Cleveland (unofficial city motto, "The Error by the Sea of Zairrer") in person to explain "irregularities" in his research team's budget.

The direct flight from Omegamons to Canopus IV hadn't been too bad, except he was famished by the time he arrived. Being served only a tiny bag of pretzels and cup of sweetened carbonated water on a flight spanning 13,413 light years wasn't quite enough to satisfy his stomach. But, a bioid attendant on the starship reminded him, as a member of PGS's "Frequent Flyer" plan, he needed only 121,398 more light-years to qualify for a free trip one way to Pheeses II, home of the largest stinkspice mines in known space.

His meeting with the Committee started out disastrously. After they accused him of embezzling 13.689 gigacredits from university accounts, he regained consciousness and demanded to see their proof. One of the committee's multispecies members pointed with its pseudopod to the spreadsheet displayed on a holoscreen.

"Figures and computers," it splotzed, "never lie!"

Subsequent investigation, however, revealed a programming glitch had made the ultra-advanced, quantum-tunneling, parallel-processing nanochips in the university's main computer believe that one plus one equaled two million. A recalculation using pencil and paper showed his accounts did, in fact, balance. The Chairthing of the Committee shrugged its equivalent of shoulders and blurpled at him, "Never mind."

Then there was that oh-so-helpful travel agent who'd booked him on this return flight. "The next direct flight to Omegamons won't leave for three standard days," the Causidician chirped.

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"But, if you don't mind a brief layover, I can schedule you for a flight that leaves tomorrow to Nineveh 6, Pan Galactic Spacelines' main hub spaceport. It's way out in the middle of nowhere, but you can catch a connecting flight there that goes right to Omegamons."

Brief layover indeed. Kroosew wondered what color the travel agent's puce face might turn if he squeezed its neck "briefly."

Exhausted, he stopped to rest. Nearby an amphibian-like hermaphrodite from Antares IV seemed to be mating with itself to pass the time. And a little farther away three fellow humans had spread their clothes on the floor and were *definitely* doing it.

For a moment he considered inquiring whether they'd be interested in making it a foursome. But, right now, he felt too low to hold up his end of the partnership.

Turning around, he squinted at the flight status display screen in the distance. It still said, "DELAYED." A gesticulating verdant decapod was arguing with a smaller version of itself standing at the flight attendant's post.

Then he realized the smaller alien *was* the perky erstwhile human female he'd spoken to earlier. The PGS promotional holo they'd shown on the flight here proudly announced its flight attendants were now equipped with "chameleon capability." Their biosynthetic "flesh" and inner support structures automatically molded themselves into the form of whatever species they were assisting. Admittedly, a clever method for placating irate passengers—presenting them with a reassuringly familiar and, theoretically, more trustworthy "helper."

Sighing, Kroosew resumed his endless lonely trek. Every seat, no matter what size or shape, was occupied. As he trudged along it felt like a great weight was strapped to his back. With every leaden step he took, he and his bags seemed to get heavier and heavier.

Then he realized they *were* getting heavier. The terminal was designed to accommodate sentients from planets with many different ambient gravities. He'd wandered onto one of the gravitational gradient pathways between weaker and stronger artificial gravity fields.

Nothing to do but go back the way he came. After walking several hundred more meters he had his first glimmer of good luck. A reasonably humanoid alien rose on its three legs from a nearby seat. The Lactomagnyzian pulled its flowing chalk-colored robe down from around its waist, and trotted contentedly away.

Rushing to claim the vacated place before something else did, Kroosew stopped himself from collapsing onto it just in time. The seat cushion was covered by a mound of dark odiferous pellets.

But as he watched the pile of alien souvenirs sagged and diminished, seemingly disappearing into the cushion. Then he remembered that promotional holo also praising the pristine sanitary conditions in PGS facilities.

Busy, indefatigable nanoscrubbers incorporated into the very structural materials keep our floor and seating so hygienic you could even eat off them. Or, depending on your species' digestive system, even eat them yourself!

Kroosew gingerly settled into the now-sparkling seat, reveling in the excruciating pleasure of simply resting his legs. But he nearly jumped out of his hard-won resting place when something growled thunderously into his ear.

The sentient seated on his right resembled a shaggy teddy bear. Its two soulful eyes looked timorously into his, as if asking for a hug.

Except the alien was a bit more than snuggle-sized—over three meters tall, and about half that wide. The six largest fangs hanging down from its upper jaw were longer and thicker than Kroosew's leg. Its claws resembled machetes, and clicked together like someone preparing to carve a turkey.

For a long time the megacarnivore

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scrutinized him from a culinary point of view. Then, apparently deciding he was too inconsequential a morsel, it lifted its nearly one thousand-kilogram mass from the reinforced seat and began stalking a meatier creature whose species Kroosew had never seen before. The obese grape-colored ungulate several rows away grazed placidly from a large bag of leaves, blissfully oblivious to its fate as the predator circled ever closer.

It'd be terrible to see what happened to that poor purple bovinoid, Kroosew reflected—but much worse to *be* one.

The sentient seated on his left seemed less dangerous. It was about his size, and didn't have any obvious body parts for slicing, biting, cutting, or chewing. A half dozen multijointed limbs radiated out from either side of a featureless pink globular body. A black derby hat was perched atop a large pale lump he assumed was its head. One of its two-fingered hands held a rolled up umbrella.

The alien unfolded a limb that Kroosew took and shook reluctantly. It spoke in a basso profundo from a nose-like bump rising from where its navel would've been, if it'd had a navel.

"I say, old chap, aren't you a human being?"

"So I'm told."

"Pimplonian, myself. My name is—" The creature gave a minute-long musically modulated toot that sounded and smelled like it'd dined recently on refried beans, garlic, and onions.

It quivered affably. "Splendid sentients, you *Homo sapiens*. Been studying for the last four standard years on your species' original planet of Earth. Just received my Doctorate in Intersentient Philology at Oxford University, don't you know? Found our two species have much in common. I'm an omnivore too."

"Now that you mention it, we do almost look like twins."

"Indubitably!"

Apparently they didn't teach sarcasm at Oxford. It snorted, "Been waiting here long?"

"A week!"

"Bit longer for me. When I arrived, I wasn't in a family way."

It patted the derby-covered bulge Kroosew had mistaken for its head. "Deuced inconvenient. But when the old hormonal biorhythms surge, there's no reasoning with them. Based on my observations, it's a characteristic I believe we also share with humans. Fortunately, another member of my species was available and happy to assist."

Kroosew muttered politely, "Congratulations. When are you due?"

"Actually, old bean—right now."

The derby flew several meters upward as a geyser of puslike fluid exploded from the top of the creature. Kroosew wiped the viscous stinging goo from his eyes and saw a writhing monstrosity tearing its way out of the gaping pocket torn in its parent. Baby stared at him with three tiny eyestalks, its dozen mouths filled with needle-like teeth smacking hungrily.

"I say, old chap, would you please pull my larva out the rest of the way? Careful of the claws. There's no known antidote for the venom on their tips."

Kroosew leaped up and grabbed his suitcases. The fetid fluid covering his clothes and hands was slippery, but he kept his grip on their handles.

"Uh—sorry, but I've got to check on my flight!"

The Pimplonian, still keeping a stiff fleshfold above its speaking orifice, turned to the octopoid traveler spread out on the seat to its left. "I say, old sport. Mind lending me a tentacle?"

Stumbling away, Kroosew peeked back over his shoulder. The obliging octopoid lay on the floor, unmoving, as the newborn clutched in its remaining tentacles eagerly enjoyed its first meal.

"Can I help you, sir?"

The flight attendant had changed back into a redheaded human. Her smiling gaze sensitized him to the fact his pants were still around his knees.

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Pulling them up awkwardly, he spluttered, "Yes, you can get me on my flight before anything else tries to eat me!"

"Oh, I hope you didn't forget my advice to avoid 'Megacarnivores Only' restaurants!"

"No, I went to a restroom to clean up after a little 'accident.' A *toilet* tried to bite me!"

The attendant smiled at him patiently. "The porcelain appliances we provide for human excretory functions aren't designed to do that, sir."

"Well, this one did! I even made extra sure before I went in that the restroom was for male humans. I didn't recognize the word on the door, but the little outline figure looked right!"

"Was the figure blue, sir?"

"Well—no, it was red."

"That explains your unfortunate experience. You inadvertently entered a facility reserved for the unisex natives of Sytonurbukyt IV. They look remarkably like human beings. However, unlike your species' flabby texture in that area, their buttocks are hard and hornlike. Therefore, to maintain proper hygiene, their toilets contain trained *bytuarse* beasts. Their burrlike teeth are geneticallly engineered to scrape and abrade away any residual waste matter on the patrons after the toilet is used."

"Believe me, I'll remember that next time!"

The flight attendant beamed happily at his wise resolution. "By the way, sir, I have good news for you!"

Kroosew felt as if the artificial gravity generator had been turned off. "Finally! When will you begin boarding?"

"I'm afraid the starship for Omegamons still hasn't arrived yet. However, PAIN has located the luggage you checked in. It was inadvertently placed on an economy class sublight generation ship bound for Noivilbo II. When the ship reaches its destination in 213.8 terrestrial years, we'll have them shipped back to you on the return flight."

His spirit broken, Kroosew pleaded, "Is there any place a little quieter and less crowded I could wait until my flight's ready?"

"I'm sorry, sir. PAIN informs me the average total biomass of sentients within all our waiting areas is approximately the same—1,319,564 kilograms, plus or minus 289."

Kroosew sighed pessimistically. "Well, if I'm lucky, I'll find the one with the minus 289 kilograms."

"There's another alternative, sir. PGS has recently instituted a new service for its customers. For a nominal fee, you can use a stasis chamber."

"A what?"

"An enclosure whose contents are kept in a state of virtually halted atomic activity. The occupant experiences what seems like a deep restful sleep. Relative to the universe at large, time will 'stop' for it."

Kroosew frowned. "You mean like suspended animation."

"Stasis and suspended animation are, in their technical methodologies, quite different. However, the end results are approximately the same. This service would eminently meet your wish for solitude and, at least subjectively, a shortened waiting period."

"At this point, I'm willing to try anything!"

She pointed to one of the interminably long corridors leading from the waiting area. "To reach the stasis chamber, go down Concourse No. 413 exactly 3.13 kilometers. Turn right at the 'Krispy Krigleworms' food stand. Walk straight 2.13 kilometers till you reach the official Nineveh 6 souvenir shop, where we have a special today on upper garments suitable for humanoid species imprinted with the legend 'My beezulgorb went to Nineveh 6, and all I got was this lousy dilworf!' Turn left and look for the orange sign saying 'Stasis Chamber' in 113 standard Galactic languages. You can't miss it."

"Fine!"

Kroosew took several steps in the di-

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rection the attendant indicated, then stopped. "You *will* let me know when my flight comes in, won't you? All I need now is to 'oversleep' and *miss* it!"

"Have no fear, sir. I will personally ensure you reach your final destination of Omegamons as soon as possible."

Not entirely reassured, Kroosew resolutely put his head down and began his long journey. He didn't hear the attendant call after him, "And please let me know what you think of this new service. You'll be the first sentient to try our stasis chamber!"

When Kroosew finally reached his goal his limbs had lost all sensation. The orange sign on the wall spelling "Stasis Chamber" beckoned hypnotically to him.

But its siren spell was rudely broken when he read the fine print beneath those words, telling how much the "nominal fee" to use it was. To pay for it he probably *would* have to embezzle from university research accounts. But, if it maintained his sanity, it was worth the risk. Even a nice quiet prison seemed appealing right now.

He pressed his palm against a metal plate to authorize payment. Immediately a previously invisible narrow door swung open from the wall. There was just enough room for him to stand and squeeze his suitcases in with him. The coffin-sized chamber was illuminated inside by a harsh yellow light. As he started reconsidering the wisdom of using it, the door closed automatically.

Suddenly claustrophobic, Kroosew looked in vain for a knob or button to open the door. Long-repressed memories of stories he'd read as a child flooded back to him. The terrifyingly detailed accounts by that ancient Terran writer Poe about being buried alive—the victim clawing frantically and futilely at his coffin lid until finally suffocating in endless agony!

Then the light inside the chamber softened to a soothing azure. He felt his cares and worries fading away, his mind and body slipping into a deep restful sleep . . .

"Time to wake up, sir."

What? It felt like he'd closed his eyes just three minutes ago.

The attendant was standing at the open door of the stasis chamber, looking fresh and vivacious. "Please follow me."

Kroosew hoisted his suitcases, praying this wasn't another false alarm. As he followed his companion's clicking echoing heels down the winding corridor he began to realize something was different.

The spaceport was empty and quiet. No milling throngs, no caterwauling babel of countless alien languages. Just the attendant and him, walking together like two lovers on a lonely beach.

When they reached the silent waiting area he dropped his suitcases, convinced he was hallucinating.

"Where is everybody?"

The attendant glanced at the vacant cavernous room. "They all left long ago."

"Well, it's good to see some efficiency for a change. Although I can't say I'm pleased my flight's the last to arrive. Can I board it now?"

"I'm afraid the starship you were to travel on never arrived here at Nineveh 6, sir. It was hijacked en route by members of the Symbiotic Liberation Front, a group adamantly opposed to sentients travelling on starships. When they belatedly realized *they* were travelling on a starship, they directed the ship back to Omegamons III, intending to disembark immediately."

She flashed him a gleaming smile. "Unfortunately, shortly after you left their system, the Omegamonians became engaged in a venomous theological controversy regarding the phanos egg ritually offered to their sun, a.k.a. the 'Great Scrambler of the Cosmos.' While the orthodox majority demanded it be broken at the traditional pointed end, a schismatic sect insisted the rounded end was more pleasing to their deity.

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"The Omegamonians decided to take their dispute to a Higher Authority. After studying your own textbook on stellar evolution and articles on imaginary matter, both groups directed their combined psychic energy toward the imaginary matter in their sun—dramatically increasing its density and transmuting its core to a critical amount of iron. Their world, your research team, and the starship were all vaporized with the rest of the system when Omegamons subsequently collapsed in on itself, and became a Type II supernova."

Kroosew fell onto an empty seat. All his colleagues, all their work—gone, destroyed. His eyes drifted toward the ceiling, as if searching for the ghost of Omegamons among the other—

For a long time he stared upward, paralyzed with confusion and terror. Finally he whispered, "Where are the stars?"

The attendant continued, "However, out of this tragedy came the most important discovery in recorded history. Like you, your esteemed fellow astrodynamicist, Dr. Hzabigolboob, was also visiting his/her home planet when that catastrophe occurred. Their subsequent research confirmed the role of imaginary matter in the 'Omegamons Incident'—and showed the path to the salvation of the universe. By the time the good doctor died some seventy-seven years later, showered with riches and worshipped as a demigod by half the Galaxy, the great project uniting all known sentients was well underway."

"Huh? You make it sound like—"

Cold sweat formed under Kroosew's armpits. "How long have I been in that stasis chamber? And why can't I see any stars up there?"

The attendant beamed, "For eons, countless intelligent beings focused their psychic energy on increasing the mass of all imaginary matter in the cosmos. When they finished, the total mass of real and imaginary matter in the universe was twice the value needed to halt its expansion. Our universe was no longer 'open,' but 'closed.' Since then innumerable civilizations have risen to glory, then crumbled to dust. The races that created them have long been extinct. But all those sentients died consoled by the knowledge that the present universe *would* ultimately collapse in the 'Big Crunch'—and a new one would be born, where intelligent life might evolve again."

Kroosew leaped up and grabbed her shoulders. "*How long have I been here?*"

Then he noticed the badge on the perpetually self-repairing attendant's uniform. The one showing the number of years she'd been in service.

It read "113,459,238,485.28665."

The last digit turned to "6." "I'm afraid it's taken a bit longer to reach your destination than originally anticipated, sir. Pan Galactic Spacelines declared bankruptcy for the 194th time several hours after you entered stasis. Unfortunately, PGS's creditors decided not to let it try reorganizing once again, or lend it more money. They deemed Nineveh 6 too costly to move or use, so it was simply abandoned."

Kroosew peered up at the featureless void above him, all its familiar stars long burned out, their planets cold and dead. The homogenous glow above him must be the cosmic background radiation from the "Big Bang," made visible as it became hotter with the onrushing collapse of the universe—washing out the faint light of whatever dim stars still existed.

Realizing the futility of it all, he let go of the unresisting attendant. "Why," he whispered. "Why didn't you let me stay in stasis? Why wake me up now to tell me I may be the last intelligent being left in the universe?"

"Indeed you are, sir. The universe has now contracted enough that all the accumulated knowledge and wisdom of every civilization that's ever existed have come within range of PAIN's scanners, and are now within its database. It informs me the last sapient being beside

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yourself expired 1,231,346,598 years ago."

He moaned, "So now I get a ringside seat to watch the 'Big Crunch'—before I die too."

"Oh no, sir. The universe will not achieve singularity for another 80,234,134 years. Well beyond your expected life span."

"Then I'll starve to death instead!"

"Dear me, no. Like the rest of this facility, the food synthesizers are self-maintaining. They continue to work as well as when you went into stasis. Would you like a complimentary bag of pretzels?"

The first shock was wearing off, and Kroosew was beginning to accept his fate. Although staying here for the rest of his life was hardly what he'd planned on, there were compensations. There'd be no more arguing with obtuse university committees, or waiting for starships that never came. The spaceport would provide him with food and shelter. For the rest of his life he could study and contemplate all the mysteries of creation contained within its computer database.

A simple, but fulfilling life. Like that legendary story of a sailor on Earth's oceans in ancient times, shipwrecked and washed up alone on a desert island, with all the things he needed to meet his basic needs. Well, all but one need—

Suddenly long-repressed hormonal biorhythms surged within him. As a late-Romantic symphonic melody by a long-decomposed Russian swelled in his memory, he gazed at the redheaded attendant in a new way. Her perfumed rosy cheeks. The mouth that always smiled so invitingly. The seductive curves beneath her formfitting uniform.

And if she wasn't *really* a woman—well, nobody's perfect.

Shyly, tenderly, he took her hand in his. It was warm and soft. He even thought he felt a pulse—proof she had a heart, or equivalent circulatory pump, beating deep within her, only for him. It was as if she understood that he'd been celibate for much longer than any man should be.

"Is there anything I can do for you, sir?"

"Oh, you have no idea! And please, don't call me 'sir' anymore. My name is Robinson."

"Alright—Robinson."

She said it so beautifully—this gorgeous creature who'd taken care of him nearly forever, always so accommodating and helpful. But before he enfolded her in a passionate embrace, there was one final question he must ask her.

"Why did you wake me now, instead of ages ago?"

"Because, Robinson," she whispered, "I promised when you first came here that I'd make sure you reached Omegamons."

Kroosew frowned. "I don't understand. You said it became a supernova."

"Yes. But as the universe has contracted, the positions of its remaining constituents relative to Nineveh 6 have also changed. Objects once light years away from this spaceport have now moved much closer."

"I still don't—"

"I'm sorry PGS couldn't fly you to Omegamons as originally scheduled. But now, your long wait is finally over. I removed you from stasis because you'll soon be reaching your final destination."

"But there is no Omegamons anymore!"

"Oh, but there is, Robinson. Just not in the form you remember."

Thirteen seconds later the massive gravitational tidal forces assaulting Nineveh 6 exceeded its design tolerances, and the spaceport and everything inside it were crushed and utterly destroyed. But just before the black hole created when Omegamons became a supernova wandered too close to the doomed facility, Kroosew heard the flight attendant say, "I couldn't help you *go* to Omegamons. But, by waiting long enough, I made sure you got there the other way."

With a last sweet smile she said, "Omegamons has come to you!" □

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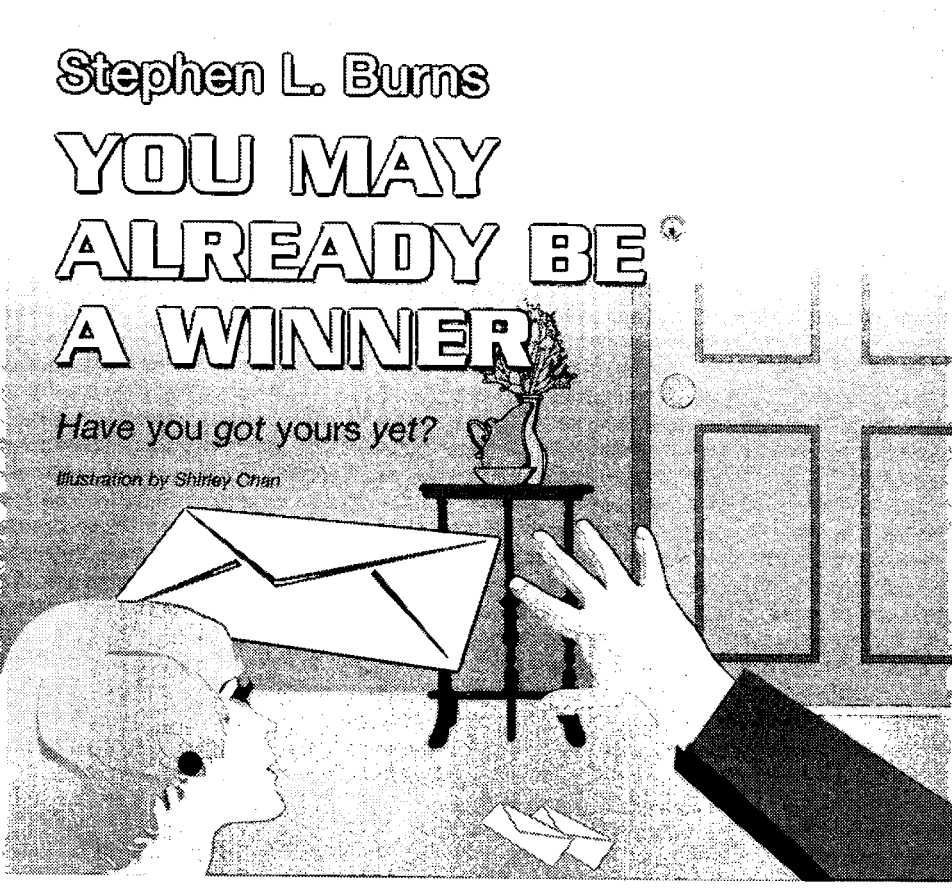
Stephen L. Burns

YOU MAY ALREADY BE A WINNER

Have you got yours yet?

Illustration by Shirley Chan



Dear Stan,

Enclosed is *Brush with Destiny*, sure hope you like it. I'd be kinda surprised if this wasn't the first yarn you've ever gotten about house-painting in space. Chalk it up to many hours spent working on a four-color Victorian "painted lady," and considerable musing on how much easier it would be if I could just *float* up to where I needed to be. Man, I hate ladders.

Far too consummate a professional to waste your valuable time trying to talk you into buying the enclosed (an option I highly endorse, by the way) I *do* want to buttonhole you for a few minutes.

You see, Sue-Ryn and I have gotten tangled up in something so bizarre it buries the needles in our personal Weird-O-Meters. These are internal devices which, I might add, years of doing Renaissance Faires have built up to Super Heavy-duty Industrial Strength. I know you're busy, but trust me, I'm talking about a world-shaking turn of events here.

Just to get your attention and to prove that we're talking capital "S" Serious Stuff, consider this: I may be taking a trip. A *long* trip. That's right, *me*, the guy who tends to emulate the Sphinx, travel-wise. I may not be going anywhere this time, either, but I am not optimistic. It's probably gonna happen.

This whole thing started one fall afternoon a couple months back. I was working over on the north side of the island, remodeling a kitchen. The phone rang twice, went silent, then started ringing again. That's the signal Sue-Ryn uses to make me pick up when I'm working at someone else's house. So I answered.

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"Hey, love, what's up?" I said.

"Steve, you better come home," she said, sounding seriously freaked. "Right now."

"What's wrong?" I was trying to sound calm, but inside my head a dozen small to large disasters are suggesting themselves, everything from hurt relatives to vehicles in the ditch to exploding hot water heaters.

"We got—" A pause to collect herself. "We got something really strange in the mail."

My blood pressure drops a few points, but only a few, as audits, lawsuits, and disconnect notices suggest themselves under the heading of Bad Mail. Before I could ask more about it, she pleads with me to just come home right now, *please?*

I tell her I'm on my way. Shut down the radio and heat, lock up the place, jump in the Beast and roar home at flank speed. The whole time I'm trying to guess what could creep her out so. A ten-thousand-dollar Visa bill? A Cadaver-O-Gram? Letter bomb? Vile crap from some hate group?

By the time I did a high-speed power-slide into the driveway I was pretty nerved up myself. I explode from the car, race to the house. "OK, I'm here!" I bellow as I get inside.

I don't know what I expected to see. I do know the sight that greeted me wasn't one of the possibles chalked up in the smeary blackboard of my imagination.

Sue-Ryn's standing there in the living room. Mail is scattered all over the floor. The object she was staring at with the fixed intensity of a cat watching an owl (and which drew my eye toot-damn-sweet) was this envelope floating in the air before her at about eye level.

Yeah, *floating.* As in hanging there all by its own self. To make matters even more interesting, when I entered the room it turned in my direction and did this little mid-air curtsey, as if to say *You made it! Glad you came!*

I stop, blink, undergo a brief but intense reality crisis. I know I'm seeing what I'm seeing because it's still several feet away. Birdwatching, I can spot stuff a mile off, but over the last few years it's gotten so that anything sneaking closer than arm's length gets a tad fuzzy.

"*It came in the mail,*" Sue-Ryn says heavily, her voice making it sound like the title of a B-grade horror flick.

"Letters do that," I answer as I make my way over to her.

"But not *this.*"

"No, not hardly."

"What do you think it *is?*"

"Fan mail from some flounder?" I joke weakly, quoting an old *Bullwinkle* line used a lot around our house. I get a laugh, but not much of one.

"I brought the mail in after Glenn came," she explained as I reached her side. "Started sorting the orders and bills from the junk. When I touched this thing it changed color and floated right up out of my hand. I let out a yell, jumped back, tripped over Boomer. He's still hiding under the kitchen table." Our dog Boomer—whose middle name happens to be Underfoot—makes the Cowardly Lion look like the Terminator.

"What color was it before?" I ask, my mouth sort of running on automatic pilot. When you fix stuff for a living you ask this sort of question by habit. Chromatropic hovering mail wasn't really on my *been there, done that* list.

"Plain white." Now it was the most amazing—excuse me, *astounding*—blue I'd ever seen, like distilled sky.

"Any idea who it's from?"

She just gives me The Look. You know the one a hapless boob of a husband collects when he asks his wife a dumbass question, one she considers so utterly boneheaded it's not worth dignifying with any other response.

I duck my head meekly. "I'll take that as a no." After a few moments more spent considering our Mystery Mail I sigh and mumble, "Guess there's only one way to find out."

I reach out and gingerly close my fin-

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gers around the envelope. The second I do it lets out this low musical tone, like a string from the bottom register of a hammered dulcimer.

"What was that?" Sue-Ryn asks nervously. It's my turn to give her a milder version of The Look, one that basically says: *How did I get to be the resident expert on floating musical mail?*

Back to the task at hand. The envelope doesn't resist as I draw it closer, it comes along quietly. Like I said before, the color of the thing makes it seem like I'm holding a chunk of distilled sky. It wasn't made out of any kind of paper I'd ever seen. Nor was it plastic, Tyvek, or any other material I'd run across. The best I can do is say that it felt like silk, although it wasn't cloth either.

On the front it read "STEPHEN L. BURNS & SUE-RYN HILDENBRAND-BURNS" in a nice sans-serif font. No address. Where the stamp or bulk mail permit should have been there was this hologram sort of thing. Remember those holographic stamps the Postal Service offered a few years back, the Space ones? Those were pretty primitive; you had to have the right kind of light and hold them jussssssst so to see them. Not this puppy. A little tiny orange sun hung there half an inch off the envelope's surface, pinpoint planets wheeling around it. I could even see even tinier moons wheeling around them. BTW it wasn't our sun or our planets.

"Any return address?" Sue-Ryn asks from behind my shoulder.

"Nope." I'm still staring at the hologram, and suddenly it hits me. I can see every detail plain as day even without my reading glasses!

"Nothing to show who it's from?"

I shake my head. "Not unless a version of Publisher's Clearing House from the year 2200 and based at another star system has figured out how to send junk mail into the past." Scary concept: two-hundred-year magazine subscriptions.

My wife frowns, prettily. "What makes you think it's *Them*." That's our term for the faceless, implacable forces of evil that plague us with endless junk mail, and storm window or long distance carrier sales-calls at dinnertime.

I point to the top of the envelope. A line of print has appeared in glowing dots of ruby light. It scrolls across the envelope again and again like a marquee. What does it read? You guessed it:

YOU MAY ALREADY BE A WINNER!!

"This is *your* department, my love," I say as I try to hand it to her. She's the one who fills in all the sweepstakes thingies. I take out the garbage. Division of labor is the secret to a successful marriage.

"That's OK," she replies, backing away. "You open it." Her tone makes it pellucidly clear that as Guy of the House it's *my* job to deal with anti-gravitic holographic mail.

Usually I just blow this sort of stuff off, sending it straight to the recycle bin. I figure I'm a lot more likely to get hit by lightning or get smutched by a plummeting Chinese satellite than to win a million dollars. Now if first prize was three tons of steaming fresh manure directly delivered to your living room I'd probably win for sure. . . .

But it isn't every day you get levitating junk mail.

"What the hell." I light a cigarette, only a minor stall tactic, then turn the envelope over. On the back is this square of star-flecked blue-black, surrounded by animated script that reads: "PRESS HERE TO OPEN." *Great,* I think, *mail that opens as easily as an aspirin bottle.*

I take a puff of my smoke then touch the square. The envelope lets out another musical tone, then sort of *moves* in my hand and swims before my eyes. The next thing I know I'm holding a letter sized sheet of amazing—excuse me, I keep doing that, *astounding*—blue whatever-it-is. Sue-Ryn and I exchange a *How the hell did it do that?* look, then we both begin to read. Her looking over my shoulder, presumably still using me as a blast-shield.

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"CONGRATULATIONS LUCKY EARTHLING!!!!" it begins. After a lead like that you have to keep reading. We did, anyway.

We are the Oronomno, and soon we will be visiting your lovely blue-green planet! We come in peace, hoping to institute mutually beneficial diplomatic and trade relations between your people and ours! We are a peaceful, fun-loving people, interested in and most excited by your various arts and social inventions! For access to these great cultural treasures of yours we will offer various extremely useful technologies! You will be so glad you met us! We promise!!!

By now you are most certainly thinking, This sounds good, but what has it got to do with ME??? *You are, after all, an ordinary human reading a piece of unsolicited (and no doubt perplexing) piece of mail. Not an astronaut or diplomat.*

Don't worry!! We want to make unobtrusive, non-threatening contact with a broad cross-section of average humans—humans like YOU!! Study of your folkways has shown us that this is a preferred method of locating and establishing contact with individuals who would be interested in what the contactor has to offer, of advertising goods and or services, and of stimulating interest in a Special One Time Offer. Which this is!! This Junk Mail Sweepstakes methodology of yours is a splendid invention, entirely new to us, and if it proves useful to us your race will of course be generously compensated for the concept! Very generously!! Wait and see!!!

Still, you are asking, WHY ME???

Here's why!! Because this is your LUCKY DAY!!!

You are not alone! Both in the universe, and in having been contacted by us! Several thousand of these offerings have been inserted into your mail system worldwide! Those who respond—and we do hope you are one of them!—will be automatically entered into a drawing for a wonderful, literally OUT OF THIS WORLD PRIZE!!!

What, you ask? Is it a million dollars? A fine luxury automobile? Perhaps a high-performance watercraft? A lifetime supply of citrus fruit? No, lucky human, what we are offering is far more terrific than any offer you've received before!! Of that we are certain!! Then what is it, you ask?

We want you to be one of the one hundred lucky humans who win a fabulous FOUR DAY ALL-EXPENSE-PAID VISIT TO THE VIRTUAL ORONOMNO HOMEWORLD WE HAVE CONSTRUCTED ON THE PLANET VENUS!!!

Never heard of the place, *you are most assuredly thinking. Of course not! We just built it last week! Besides, this is why we are contacting you! We want YOU to be among the first to taste some genuine old fashioned downhome Oronomno hospitality!!!*

Let us tell you, lucky earthling—and your lovely mate reading over your shoulder—the virtual Oronomno homeworld contains all the amenities of the original! Once there you can shop in stores operated by our people and other races with whom we trade! Floatglide over Klooth, the miniature version of our most beautiful city! Taste exotic foods such ditthral, roool pie, and ylo under glass! Relax on the terrace of the splendid Hotel Oh, watching our orange sun set over the fuscia sands of the fabled Olmana Ocean! Game in our casinos! Watch exotic performances! And when you decide to retire for the night, you can perform your race's mating ritual in Hotel Oh's zero gravity bedsuites! There are thousands of out of this world wonders waiting to be experienced, but ONLY IF YOU RETURN YOUR ENTRY!!!!!!!!

Why are we offering such a fantastical prize? What's the catch???

There is none!! Really!! We just want to meet YOU!! Think of this as an intimate get-together we are holding so

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that your race and ours can meet face to face before the Big Day arrives!!

So enter NOW!!! There is no obligation! No hidden costs! No magazines to buy! No salesbeings will come calling! Hope to see you soon!!!!!!!

There under all that was another dark blue square, this one orbited by the phrase: "SOUNDS GOOD!! SIGN ME UP!!"

I read faster than my wife. I skimmed it a second time, looking for catches, and caught up with her at the end.

"Well," I said in a bemused tone, "We've never been to Venus."

"We never go much of *anywhere*," she pointed out. There was this real faint note in her voice which seemed to suggest that I'd been the reason we'd passed up several previous chances to visit another planet and meet an alien race.

I stared at her. "You mean you'd *go?*"

She bit her lip, then shrugged. "Sure. If *you'd* go." Meaning the decision was mine.

"Thanks," I grumbled. My perfectly sensible natural inclination to avoid travel at all costs had already begun kicking in, and myriad objections, excuses, and considerations both practical and admittedly far-fetched were popcorning in my head.

Unfortunately it wasn't quite that simple. My equally natural cynicism and pessimism sort of buttered the popcorn with the thought, *Right, like you're going to win.* Sweepstakes odds—for an all expenses paid alien vacation giveaway, no less!—made it safe to exhibit a cheapjack largesse and say:

"Sure. What the hell. If we win I'll go."

I thought I was home free until last month. It was a crummy day, and I was working upstairs in my office when the mail came. I went downstairs, grabbed a jacket and ran out to get it from our roadside box. As I was gathering up the ads, magazines, and real mail, another floating letter leapt out of the pile and hung there in the air before me. We seemed to stare at each other, me with dismay, and it as smug as first class. If that wasn't bad enough, I couldn't help noticing how the rain seemed to avoid it.

I knew this couldn't be good news—at least not what I would consider good news. So I just left it hanging (so to speak) and headed back for the house.

Stan, the damn thing *followed* me! Some of these junk mail bastards can be satanically persistent, bombing you with an endless flood of multiple mailings. We've all grown used to that. But this thing was the Hellhound of junk mail. When I saw what it was doing I started to run. It just moved faster, zipping along beside me. I tried to slip through the door and leave it outside, but the damn thing flicked past me.

Sue-Ryn had come down from her workroom and was standing by the bottom of the stairs. "Any good mail?" she asked.

"Not hardly," I growled, making a futile grab for the envelope. It evaded me and flew straight to her like a trained bird, landing gently in her hands.

She looked down at it, then back up at me with a big grin.

"Guess what?" she crowed. "We're semi-finalists!"

Last week another letter came.

That's right. We frigging *won.*

Tomorrow at two we're supposed to have our bags packed and be ready to go. No UFO's in the back yard, they're going to beam us right out of our living room and straight to the front desk at the Hotel Oh. I can't even plead logistics as a reason to cancel at the last minute. According to the prize packet they will see that we are, and I quote: *"for our convenience expeditiously returned to our own space-time continuum at a point .75 minutes after we depart!"*

OK, you've read all this and you're probably thinking: *But this is wonderful! How can Burns bitch about the chance to see both another planet AND*

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the virtual representation of an alien civilization, hobnob with other aliens AND all of this expenses paid, no less!

You're right, of course, but when you get right down to brass tacks I'd *still* prefer to stay home. Even if I'm only going to be gone .75 minutes as far as home is concerned.

No, while I'm not crazy about meeting new people, neither am I afraid of meeting these aliens. They seem nice enough, although their *Up With People* enthusiasm may not wear well. Our winners' packet had several pictures of them. You know that Furby toy? Cross one of them with a Munchkin and you've got your average Oronomno Joe. The Hotel Oh looks *quite* nice.

There's only one thing about this whole thing, and about them, that frightens me.

These folks have matter transmission. Time control. They can build a pocket environment on *Venus*, for chrissakes! They want to be liked. They want to be accepted. They want to trade.

We have just given this technologically superior race the concept of *junk mail*, and they've already proved to be better at it than we are.

I'm going on this trip, I guess. I have reservations, but we have reservations. I'll drop you a line at some future point to let you know how it went.

In the meantime, be warned and pass the word.

There's an alien invasion coming. A benign invasion, but an invasion nonetheless.

Don't bother watching the skies.

Watch your mail.■

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MILLIMETER GRAVITY AND THE SUPERSTRING WALL

Why is gravity so weak? Why are the color forces between quarks so strong? In the standard model of particle physics, why are there so many different energies at which distinct fundamental forces are supposed to "unify," and what determines these widely separated energies? The answers to these questions may be provided by extra dimensions curled into loops a millimeter around. In other words, our universe may be only a millimeter across, in directions we are not yet able to perceive. In this column we'll consider millimeter-size extra-dimensional loops and their implications.

The idea of extra dimensions in physics can be traced back to 1919, a time when Einstein's general relativity was just emerging as the standard theory of gravity. Theodor Kalusa, a German mathematician then teaching at the University of Königsberg, sent a paper to Albert Einstein. In it he demonstrated how, by adding a fifth dimension to general relativity, Maxwell's formulation of electromagnetism could be incorporated into the theoretical framework of general relativity, a bold first step in formulating a "unified-field theory." Einstein provided encouragement, and Kalusa was able to publish his work in 1921. However, Einstein questioned the existence of Kalusa's extra dimension because, aside from the elegance of the mathematics, there was no evidence of such a dimension. He reasoned that if we really live in 5-dimensional space-time, we should have noticed this already.

The puzzle of the missing dimension was partially resolved in 1926 when Oskar Klein, a colleague of Niels Bohr in Copenhagen, pointed out that Kalusa's extra dimension might be "hidden," provided it was "compactified" by being rolled up into a tiny loop of small size. Kalusa's extra-dimensional extension of general relativity combined with Klein's idea of compactification of extra dimensions is now known as Kalusa-Klein (or K-K) theory, and after many decades of languishing on the sidelines, it has become a major theme of mainstream theoretical particle physics.

A particle that has momentum directed along Kalusa's extra dimension will travel around the Klein loop and will soon arrive back where it started. Therefore, the particle is essentially confined to a "box" of the loop dimension. This causes momentum quantization in the loop direction because only certain wavelengths can fit around the loop. What we call electric charge, according to K-K theory, is actually motion in this dimension. Thus, charge is quantized by the loop condition.

A charged particle must be travelling repeatedly around the K-K loop, even if it is at rest in normal space. If it moves, say, clockwise around the loop then it has a positive charge, while counterclockwise motion would give it a negative charge. The size of the unit charge and the strength of the electric force are inversely proportional to the distance around the loop: the smaller the loop, the larger is a unit charge. Newton's

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third law of motion (action = reaction) applied to momentum along the K-K dimension leads to the law of conservation of electric charge, and the CPT theorem connecting the reversal of electrical charge with reversals in space and time directions is given a simple geometrical interpretation. K-K theory is "powerful" because it reveals connections between seemingly unrelated physical laws.

The present "standard model" of fundamental particles (quantum chromodynamics or QCD) works too well to be "broken" by experiment, yet it is known to be a paste-up theory constructed around two dozen arbitrary variables: quarks and lepton masses, force strengths, and cross-connections between particles. All of these arbitrary variables must be put in "by hand," with no hint of their origin.

And the Standard Model is daunting in another way. It predicts that as we go to higher particle energies with new accelerators, we will encounter an "energy desert," a vast wasteland where there are no new particles and not much interesting happens until energies at the Planck scale (10^{28} eV) are reached. Since we have no prospect of coming within many orders of magnitude of such a high energy, this is a very discouraging prediction for experimental particle physics.

The Kalusa-Klein theory has become a key element of supersymmetric string theory, the best theoretical hope on the horizon for improving on this situation. String theory has an elegant mathematical structure that joins quantum mechanics and gravitation. It discards the usual view of fundamental particles as point-size objects embedded in a three-dimensional space with an additional time dimension. Instead, string theory describes fundamental particles as extended "string-like" objects embedded in ten or more dimensions. The extra dimensions beyond 3-space and time, based on K-K theory, are compactified into loops perhaps at the Planck scale, about 10^{-35} m around, and are responsible for the fundamental strong, weak, and electromagnetic forces.

For the past decade string theory has been the consuming passion of some of the best minds in theoretical physics, and enormous progress has been made. It has been realized that the many prescriptions for formulating string theory are limiting cases of the same theory (sometime called M-theory) and that multidimensional wall-like structures (called D-branes) can be found in the theory that simplify many of its problems.

However, string theory still suffers from one basic difficulty: it cannot make experimentally testable predictions. The usual feedback loop linking hypothesis with experimental test, the dialogue that is the mainspring of the scientific method, is not applicable to string theory. In its present form, it can rely only on mathematical elegance to keep it on track. This is a very precarious situation for a developing theory. But perhaps this situation is about to change.

At the beginning of this decade, a few string theorists began to question the size of the extra-dimensional loops of string theory and to ask how big they might be before the theory came into conflict with observations. The answer, which is still being refined, is a surprise. Such loops can be as big as a millimeter, provided they involve the extra dimensions that are characteristic of the gravitational force. And millimeter-size extra-dimensional loops for gravitation provides an explanation of why the force of gravity is so small compared to the other forces.

The picture that emerges from these investigations is that each 4-space location in our universe is confined to a thin extra-dimensional "D-brane wall" on which the strong, weak, and electromagnetic interactions are confined, while the gravitational interaction is allowed to expand away from this wall in

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two or more extra dimensions which loop back on themselves in a distance of about a millimeter. Gravity, in this picture, is so weak because most lines of gravitational force are dissipated into these extra dimensions, while the other forces, confined to the wall, are not similarly weakened.

There are many experimental implications of this variant of superstring theory. One is that the energy scale of unification of the strong and electro-weak forces with gravitation is much lower than the standard model would predict, and may be reachable when the next large particle accelerator, the Large Hadron Collider or LHC, comes into operation at the CERN Laboratory in Geneva, Switzerland in 2005.

But perhaps the more interesting prediction, because it will be tested sooner, is that at separation distances on the order of a millimeter, the gravitational force between two masses should become significantly stronger. This is because, if gravitational field lines are spreading out into extra dimensions compactified in millimeter loops, then when two gravitating objects are separated by distances of less than a millimeter, the extra field lines should appear. Gravity, instead of falling off like $1/r^2$ should begin to show a falloff of perhaps $1/r^4$. If r is a small number, dividing by it twice more makes the corresponding gravitational force much stronger.

Unfortunately, this effect is not easy to observe in laboratory experiments. A typical "tabletop" measurement of the gravitational force uses a Cavendish balance, a pair of lead spheres about the size of tennis balls on a crossbar supported by a thin fiber. When similar spheres are placed nearby, the force of gravity twists the fiber, providing a measurement of the gravitational force. The centers of mass in such an experiment are separated by about 10 centimeters, so the distance scale at which gravity is being tested is about 100 times larger than that at which the interesting effects should appear. If one tries to simply make a Cavendish balance 100 times smaller, the gravitational forces, which are already small and scale with the volumes of the lead spheres, become $(100)^3=10^6$ times smaller, much smaller than noise effects present in the experiment.

However, an experiment designed by John C. Price and his co-workers at the University of Colorado promises to measure millimeter-scale gravitational forces. It will use a vibrating blade oscillating close to a "gravitational pickup" square that is isolated inside a shielding sapphire box and is part of another system that oscillates at the same frequency. The experimenters calculate that the varying gravitational force transmitted through the box should drive the oscillations of the pickup system and permit a determination of the gravitational force strength at millimeter separations. Other groups specializing in gravitational physics experiments are also designing experiments that will probe millimeter-scale gravitation. We can anticipate that in a year or so, well before the LHC at CERN goes into operation, we may have evidence for or against millimeter-scale superstring theories.

What are the science fiction aspects of a universe with millimeter-scale compactified dimensions? The plot line of my hard SF novel *Twistor* (Morrow, 1989) used a "shadow Earth," a planet-twin of the Earth occupying the same orbit around a similar sun, but made of "shadow matter," a projection of matter in an extra K-K dimension which interacts with the matter of our planet only gravitationally. Although my novel was written before the theoretical developments described above, superstring theory with millimeter-scale dimensions provides an additional theoretical basis for such an extrapolation.

Our universe is puzzling because certain expected particles have not been found. In particular, missing from our

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universe in the expected quantities are: antimatter particles (antiprotons and positrons), magnetic monopoles, and six right-handed weakly interacting particles (Z^0, $W^{\pm}$, and three flavors of neutrinos). Further, we know that 5/6 or more of the non-vacuum mass in our universe is in the form of "dark matter" that shows up only through its gravitational interactions. It is fair to ask where the dark matter "lives" and where the missing particles have gone.

The millimeter-scale superstring theory discussed above describes our universe as having the strong, weak, and electromagnetic interactions confined to a compactified "wall" while the gravitational interaction is allowed to spread out over a millimeter of distance into two or more extra K-K dimensions. A millimeter is a huge span of distance when compared to the 10^{-31} meter size of the other compactified loops. What else might lie in that millimeter? Why should there be only one such wall there?

Perhaps there are other walls wherein the missing dark matter, antimatter, magnetic monopoles, right-handed weak particles, and particles we haven't even dreamed of may reside. Perhaps there are Twistor-like shadow worlds made of normal or exotic matter, "parallel" to ours but lying on another wall, separated from ours by only a fraction of a millimeter, but completely unconnected to our world except through the effects of gravity.

Perhaps we are on the threshold of discovering these extra dimensions and our "wall" embedded in them though their gravitational and particle-physics effects. Perhaps we stand on the threshold of a doorway that leads to extra dimensions. Watch this column for further developments. □

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AV Columns On-line: Electronic reprints of 95 or so past "The Alternate View" columns by John G. Cramer, previously published in *Analog,* are available on-line at the URL: **http://www.npl.washington.edu/av**. The papers referenced above can be obtained at: **http://xxx.lanl.gov**.

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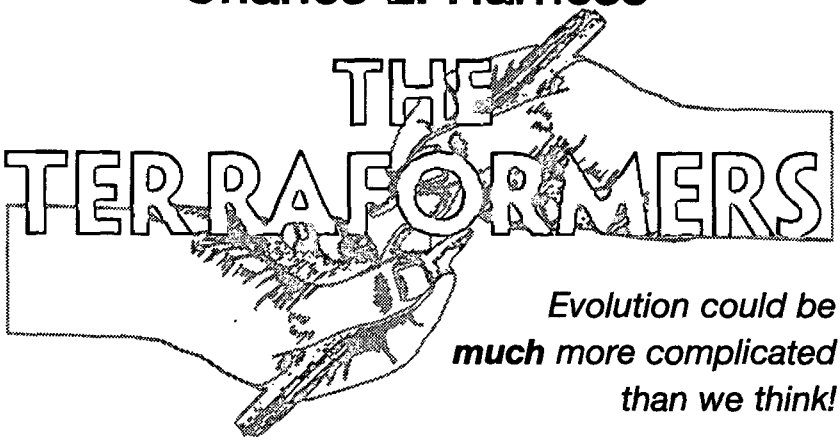
Charles L. Harness



Evolution could be ***much*** *more complicated than we think!*

Like its predecessors, the third Jaquino probe was unmanned. The tiny ship lifted, shimmered, vanished, six hours later shimmered again and set down quietly between the coils. Tests of the little vessel's instruments and attachments soon proved that it had found a world that orbited a star in a binary system in a galaxy clearly not the Milky Way, and, some experts argued, not even in the local universe. Habitable? Maybe. Everything seemed earthlike except the atmosphere, which was a blend of CO_2 and N_2. Colonists would have to live in bubbles at first, while the CO_2 was being converted to O_2.

A matter for the Terraformers, who immediately organized a full-scale expedition in a ship especially built for the occasion: the *James Lovell.*

Joan Dickens (Clairvoyants, Inc.) opined that it was suicide to name a vessel for the captain of a disaster—namely, the twentieth-century Apollo Thirteen.

Doom International announced that the Mother Matrix was screaming because of the breach in her continuum, and that time was gushing through the wound like arterial blood. Their guru cited the vision of two hands, said to symbolize an act (or maybe omission of an act—they never really pinned him down) to be done (or maybe not done) by the ship that would destroy—or save—the entire human race. One or the other. Two members of the initial expedition staff had been detected as members of Doom and had been replaced at the last minute.

When Doom expanded the potential casualty list to include the human race, then, and only then (albeit reluctantly and skeptically), the Terraformer Authority took notice. As did the Authority's major insurer, Interplanetary Mutual, who insisted that the *James Lovell* take their choice as captain, a well-known strict disciplinarian, namely F.L. Spask, an officer of twenty years' impeccable reputation in the Luna overnights and Mars weekenders. I.M. had never had to pay a claim on a ship captained by Spask.

There was a big meeting in the Executive Suite at I.M. Everybody was there: the president of Terraformers, the Licensing Officer of Interplanetary Admiralty, the Secretary of State for the Cosmographers Society.

I.M. did most of the talking. The Adjustors Unit had some earnest suggestions. "Follow the Rules, Spask. Don't fritter away time and effort. Avoid distractions—yours and . . . those people's. Confiscate things, if you have to. Get in, make the tests. You should have an answer within hours. If it's yes, start the terraforming process and get out. If it's no, sterilize the test cultures, drop the Sagan

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plaque, get out. Time may be a factor. Don't risk losing the *finestra*."

"*Fin*—?"

"*Finestra*—window, Spask. A Jaquino term. Remember? You took the crash course given by that young navigator fellow . . . uh . . . Bob Easley? If it closes while you're still out there . . . well . . . but with you in command, I'm sure that won't happen, especially with Easley and First Officer Roy Karos

"No chance for a shakedown cruise, Spask," the Licensing Officer said. "And no chance to reach an understanding with your First Officer. We know that. Sorry. Couldn't be helped. But we know you'll come through. Just follow the Rules. Keep their minds on the mission. No nonsense, no detours. Remember, billions are invested in this ship, and the Authority is entitled to a fair return on its investment."

Spask said, "I want the first liner that comes out of this program."

"And you shall have it," they told him. "Just keep your nose clean," the chairman of the Licensing Board added, unnecessarily.

Ferrol Lester Spask. He knew what they called him behind his back: "Fearless Spask." It didn't really bother him. The nickname had more or less created itself during hell week at the Academy. Nearly all the friends and colleagues of that distant epoch had by now vanished into their own careers. Hardly anybody was left who called him Fearless to his face. Sometimes he thought about his nickname. He had never encountered a life-threatening situation. He wondered, would I then be Fearless? Interesting question.

Just before departure Captain Spask granted a short, rather ill-tempered interview to the media, wherein he exuded a blend of confidence and contempt. "Predictions of disaster? It's all ridiculous nonsense. An unmanned probe has navigated routinely to the planet Navetta and returned. It's perfectly safe. Our team is made up of highly skilled professionals—the best in their fields. If Navetta can be terraformed, we will do it. If it can't, we'll come home, try elsewhere." (Full-face, hard blue-green eyes snapping, lip curled in utter disdain. The *James Lovell* in the background.) "You think eight human beings can destroy the entire human race? You're all crazy!" He was a big, burly man; he had presence; he radiated authority.

The professionals were gathered around the officers' table.

"Before we strap in for lift-off," Captain Spask said, "I want to make sure we all understand our mission. I think all of you know Terraformer's general goal: a livable planet. One we find that way, or one we can terraform. Aside from our own solar system we are not aware of any such planets. Most of the extra-solar planets probed so far have had serious flaws: gravity too high, extreme temperatures, no water, air is toxic, and so on. We then ask, can the flaws be corrected within a reasonable time, which at present the Terraform Authority has provisionally set at one hundred years. In a word, if it is not immediately habitable, is the candidate planet nevertheless terraformable?"

He paused, looked around the table, continued. "Our target planet for this mission, so-called Navetta, may be one such. The only problem seems to be an atmosphere of 20:80 carbon dioxide:nitrogen. If we can start converting carbon dioxide in its atmosphere to oxygen with good yield, I think we'll be home free. I'm told conversion to twenty percent O_2, with CO_2 below five percent, will take about eighty-five years. While waiting for the air to clear, the immigrants can live in bubbles. It's their descendants, of course, that would reap the most benefit from our work."

He studied their faces, and his own seemed to harden. "You see on the table in front of you what will be known as the Rules of the Ship. You will follow these Rules to the letter. Deviations could put the ship at risk. I will not tolerate deviations. Any questions?" A pause, a silence. "No questions, dis—"

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"I have a question," said Virginia Oxley.

He looked at her with expressionless eyes. "Ah, Dr. Oxley, our psychiatrist. Yes, your question?"

"You came to my cabin and took a print that I had hung on the wall. Captain, why did you take my picture?"

"Because it is trivia, doctor, and trivia tend to distract. Distractions at a crucial moment could harm the mission, perhaps even destroy the ship."

"You personally found the drawing distracting?"

"Yes, doctor, I personally found the drawing distracting. I believe most of our personnel would agree with me. Two hands, each drawing the other . . . something by a fellow named Escher, I think. Particularly distracting in view of certain well-known prophecies. Not to worry, doctor. When the trip is over, you'll have it back." He folded his arms on his chest and regarded her with narrowed eyes. "Dr. Oxley, and meaning nothing specifically personal, I cannot imagine a professional less likely to be of use on this trip than a psychiatrist. I'm not sure what you weigh, but I do believe that your weight should have been put in supplemental instruments aimed at ensuring ship safety."

She smiled sweetly. "Captain, let us all hope that your assessment proves correct, and that future Jaquino flights can dispense with the psychiatrist."

"Humph . . . now, if that's—"

Dr. Oxley interrupted him. "Not quite done, Captain. You also confiscated Mr. Easley's music collection. May we ask why?"

"Yes, glad you asked. Ms. Oxley, Mr. Easley's collection listed a selection long-banned on the seas and in space. Today no civilized ship will carry, much less play, "Sponge d'Automne," which was the last music played by the *Titanic*'s main orchestra the night the ship struck the iceberg."

Seems reasonable, thought Dr. Oxley.

The navigator spoke up. "Okay. But how about the picture of Mark Jaquino? You took it down from the bridge. But it was *official* . . . it was *supposed* to hang there."

Captain Spask winced. Dr. Oxley suppressed a smile. She knew the photo portrait well. It had evidently been taken shortly before the famous scientist received his Nobel. The face radiated a gentle dignity. Behind the dark glasses there were laugh crinkles at the eye corners, and under the sparse gray mustache the mouth was curved into a faint smile, almost a grin, as though he was already savoring the furor the Processo would soon arouse in the scientific establishment. Articles had been written about his blindness. Some claimed it had opened a vast new world of space-time to him and had given him the vision of the thirty-one baffling equations that contained the Jaquino Processo.

Mark Jaquino had been dead for fifty years, but Dr. Oxley sensed that as far as the captain was concerned the great Italian was still vibrantly alive, an incomprehensible eleven-dimensional career threat.

Spask addressed the navigator with cold finality. "Suffice it to say, Mr. Easley, I found the portrait . . . distracting."

Virginia Oxley was not telepathic, though from time to time she had been accused of the faculty. But she was highly skilled in reading body language, the unconscious shifts and barely perceptible motions of arm, leg, eyes, mouth, volume and frequency of respiration, and other things. These signals, taken with some knowledge of her subject, often offered surprising results.

Distraction? thought the psychiatrist as she watched the officer's face. Mere distraction far understates the case. He *hates* the great laureate. Mark Jaquino had destroyed Spask's predictable Newtonian world. Oh, of course he had taken that six-hour course in Jaquino required by the Authority. They all had. Some of us (she thought) had gone into the course ignorant and confused, but had come out enlightened. Not Spask. He had gone in misinformed and had emerged bewil-

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dered . . . and frightened. She could read it in the clenched lines of his jaws. And now he's overreacting . . . to trivia.

She guessed at his line of thought. Oh, he could probably quote the Rules of Admiralty page after page verbatim and lay out a Luna-Mars course in his head. But how about the numbers for *vermebuco*—wormhole; or the deathly critical *entrata* and *uscita*—entrance into the hole, and exit? Or what good now was a thorough comprehension of thrusters and reaction motors and tricky maneuvers in three-dimensional space when faced with a possible *sovraccarico*—overload? Not to mention the fatal *finestrachiusura*—window shutdown.

Ah, Spask, she thought, we're going to be working together for an indefinite time on an indefinite planet with an indefnite chemistry and an indefinite future. If we are ever to see home again we've got to coalesce into a working team, not one banded together to fight you. This is not a good start.

"Nothing further?" said Captain Spask. "Please prepare for liftoff in two hours. Dismissed."

Dr. Virginia Oxley was Acting Chief, Mental Health Services, Callisto. To move up to the next notch she needed to list a field trip on her bio, and when the Authority had called her to Luna for a possible assignment she had caught the next packet.

"There were originally three Doomers on *Lovell*," they told her. "We got rid of two. There's still one in the crew—we can't identify him . . . or her. That'll be your job."

She was dubious. "You don't need a shrink. You need a cop."

"They'd ID a real cop instantly. But not you. Shrink is your cover."

Somebody had said, "There's probably no real danger. Surely they must realize, if they destroy the ship, they die too."

She thought, I hope you don't reflect the general level of IQ here.

One of them said, "We might mention, they have a secret recognition code. It's in the file. Something about dinosaurs."

"How do you know I'm not a Doomer?"

The oldest interrogator, with bald pate, white stubbly beard and twinkly eyes, said, "Our people have followed you through university, med school, internship, private practice, then into the Authority on Callisto. The closest you ever came to doom was when you played Brunnhilde in your high school play. A section of Valhalla fell on you."

And they had all thought that was very funny, and here she was.

On their way out of *Lovell's* little conference room, she touched Dr. Rulain, the heliologist, on the sleeve. "Could you join me in the galley for a cup of coffee?"

She had read his file. Years ago Dr. Benjamin Rulain had pointed out to the Terraformer Authority that the galaxy consisted mostly of binary and ternary star systems, not loners such as our local sun, and that humanity must eventually seek out planets of such systems. He was too modest to claim to be the solar system's leading expert on binaries; yet he wasn't surprised when the Authority asked him to join the *Lovell*.

"History?" Rulain said. He took a sip of his coffee and looked across the table at her. "Dr. Oxley, I'm sure—"

"Virginia," she said. She noted with interest that he had one blue eye, one brown, and she wondered whether the oddity contributed to his specialty—bicolored binary stars.

He smiled. "Ben. I'm sure you're familiar with our story."

"Most of it, probably," she admitted. "The population explosion of the twenty-first century . . . colonizing Luna, then Mars, then the big moons of the outer planets. Except for Titan, gravity was too weak to hold a permanent artificial atmosphere. They had to live under bubbles. The bubble people. Like me. I was born on Callisto." She grinned. "Then what?"

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"We needed *planets*—Earth-size, reasonable gravity, reasonable temperature spread, plenty of water, breathable air. Or if not presently breatheable, at least terraformable into breatheable within a reasonable time."

"... 'reasonable time'—?"

He sighed. "A century. We never expected to find a planet with a decent oxygen atmosphere, and indeed, so far we have not. At this point we'd be happy to settle for a planet with a carbon dioxide-nitrogen atmosphere that we could terraform into useful oxygen-nitrogen within a hundred years.

"So our journeys to other suns started with the great *Hipparcos* star surveys of the late twentieth century, which measured distances and other parameters of all stars within a celestial sphere of five hundred light years. With that database we tried to identify those with planets. We looked for orbital microwobbles, Doppler shifts—the standard criteria. We found a goodly number of stars with planets, some really attractive candidates for terraforming, but most were too far out, beyond our reach, even with a ten-year sleep. So we waited." He took a sip of his coffee, frowned, put the cup down.

"And then?" she said.

"Well, it was rather a long wait, but eventually along came Mark Jaquino. His theory was published in IJM, *International Journal of Mathematics*, Turin—in 2398, without peer review, and with a cautious editorial caveat. In fact, no reputable mathematician on Earth paid much attention to it at the time. Today that issue of IJM is a collector's dream, worth thousands."

"Wormholes in the fabric of space," she said. "Shortcuts."

"Exactly. Stars were no longer light-years away. If you used Jaquino corridors and windows, and if you did it just right, the stars were weekend trips. You went back in time, *way* back, but who cared? You always returned to the present."

She nodded. "So a couple of years ago the Terraformer Authority got their big grant. They sent out unmanned probes and discovered star-planet systems in sectors of the galaxy not detectable even with the giant Hubble on Pluto."

"Correct," he said, "most likely because they were in another space-time. No matter. Planet-bearing stars now lay only a few days away from our solar system. Next came this working flight, and here we are."

She said, "And nobody is worried about moving backward in time?"

"Well, at first there was some concern. But it all amounted to nothing, nothing at all. The objection—if indeed one might call it that—yielded to the hard fact that our unmanned probes returned safely within a few hours of departure. Whether any of them had moved in time, backward or forward, was clearly irrelevant."

She took a final sip. "And this new planet, Navetta, appeared—appears—to be a good possibility?"

He laughed shortly. "Certainly worth a try. But Navetta isn't Terra. Helga Leifsdotter, our microbiologist, will have to create something there—life?—that will produce oxygen. And at this point, of course we know absolutely nothing about how life might grow on a planet orbiting a red sun in a red-blue binary system." His voice became earnest. "But it's a glorious opportunity to find out." He leaned back, took a deep breath. "Mr. Red, Mr. Blue, one cool, one hot. Each sun revolves in its own ellipse around their common center of mass. Mr. Red's single planet probably condensed millions of years ago from left-over dead primeval dust. Is it still dead? We'll soon know."

"You think the mission will succeed?"

He gave her a look she could not decipher. Annoyance? "If Navetta can be terraformed, Helga will do it."

Time to switch the subject.

"Ben, some say we don't really understand Jaquino space-time . . . that the *Lovell* is a funeral ship."

The heliologist smiled. "Don't you believe it."

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The galley buzzer sounded. "Last call for strap-in," said Rulain. "Launch in ten minutes. Maybe we can finish the mission quickly, get this character home and on his chicken farm in Maryland, and no real harm done. See you later."

She watched him leave, and was thoughtful. Not you, Ben Rulain. You *believe*, but not in doom.

"Softly, Mr. Karos," Spask said. "Clear that rise, then you can let her down on the cliff, facing the sea. That'll give us a 360-degree panoramic view and a good defensive position."

"Sir," Lieutenant Karos said quietly, "Dr. Leifsdotter will be taking samples from the sea. It will be very difficult to get the robot-scoopers back up the cliff. We'll have to send personnel down there . . ."

"Oh. Well . . . you take the conn, Mr. Karos."

"Aye, sir. I'll aim for the lagoon, under the lee of the cliff."

"A wise selection, Mr. Karos." The captain's voice was a rasping monotone. "Please proceed."

Passage through the Jaquino *vermebuco* had been swift, less than twenty-four hours by ship-time, and now several of the staff had crowded into the bridge-room to watch the landing on the big screen.

They call this planet Navetta, Italian for shuttle, thought Virginia, because after rounding its cool red sun it follows a long ellipse out toward its hot blue sun, and then home again. Just now it was completing its circuit of Red and would soon head for Blue. An unmanned preliminary probe had been here before, but had made only the sketchiest phys-chem tests, so very little was actually known about the two stars and this moonless planet.

She studied First Officer Karos covertly. His face was a mask. Interesting, she thought. We don't exist for him. He's part of the ship. The officer, an erect, graceful man, seemed to wear a slight but perpetual frown (induced, the psychiatrist suspected after reading the file, by a heavy mortgage, an ageing parent in a nursing home, and a daughter whose high school graduation he was going to miss because of this mission).

"Down," Karos said.

She had felt nothing, but she knew that the *Lovell* now rested solidly on the landward side of a tidal pond. The touchdown had gone off beautifully. She wasn't surprised.

She looked around the bridge. The captain was on the speakerphone, talking apparently to Paul Salter, the environmentalist.

The Authority had given her a file on Salter. He was not what one would call a company man. For some years he had accepted as fact (though apparently with growing gloom) that scenery had to bow to population pressures. But when asked to level Martian Olympus Mons—the tallest mountain in the solar system—to make room for Township No. 1025, he had refused, and had been put on leave and under extensive therapy, but had been brought back as environmentalist for the *James Lovell*. You don't have to do anything, they had told him. Just make a routine report.

You're not the one, Paul, she decided.

She now heard: "Gravity oh point nine six. Temperature in sunlight five Celsius, atmospheric pressure eight hundred ninety millibars. Dry basis, carbon dioxide twenty percent, nitrogen seventy-eight, remainder methane, traces of the noble gases. Oxygen zero. Strong westerly winds, silica dust storms. Local surface highly siliceous."

"Life?" Spask said.

"Estimate for this locality, zero. For the planet, data insufficient."

"Estimate for terraforming?"

"Assuming the seas will accept seeding, one hundred years."

Spask continued on the phone. "Dr. Salter, as we came in, we observed strong dust storms over many areas of the planet. What is your opinion about making the standard surface search for life?"

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"Captain, radar is, of course, useless where the dust is really thick. On the other hand, I noted intermittent clear patches, moving with the storms. I say, let's chance it, get the search satellites out. Fine resolution. We'll have good light for all the planet surface except a small initial darkside wedge, and even that will get some in a few hours."

"How long to complete the survey?" Spask said.

"Eighteen hours."

Very good, thought the psychiatrist. Did he make the calculation in his head just now, or did he have it all figured out long ago? Oh well, if there's anything out there, life . . . signs of prior visitors . . . artifacts, native or alien . . . we'll soon know. What would an artifact look like? A thatched hut? Not likely. There's probably no vegetation anywhere. An arrowhead? But no skilled Paleolithic hands to shape it. Soot-blackened cooking hearths? No—no oxygen for fires. They don't expect to find anything. They just want to be able to say they looked.

"Please go ahead," Spask said. "And will you arrange with Dr. Leifsdotter to start the seeding protocols?"

Captain, thought Virginia, you're doing fine. Keep up the good work.

"Gentlemen, mesdames, I have called this first staff meeting in accordance with the Rules." As Captain Spask made the announcement Virginia looked around the table at the specialists: Paul Salter, Helga Leifsdotter, Roy Karos, Bob Easley, Ben Rulaint, Carl Jones.

She studied Second Officer Jones covertly. According to his file the lieutenant was fresh out of the Academy. Thin blond hair. He had a tendency to close his eyes, as though his mind might be miles away. Or perhaps he was just projecting ship movement. Or even what he'd order at the next mess. Lieutenant, she thought, would I be rushing to judgment if I tagged you as our secret Doomer? Maybe. What would happen if I tried the dinosaur password on you? But let's not do anything stupid. Let's wait a bit. Check out everybody.

Leifsdotter was a heavy woman, and Virginia had understood there had been some question as to whether she could make the maximum weight limit, but that the requirement had been waived by acceptance of the underweight navigator. Virginia had read her file. A curious woman. She seemed most at home in another world—her own microvillage of invisible living cells, where everybody knew everybody. She was famous in minor ways. She had discovered several new species of amoebas. Some said she talked to them, like a spinster talking to her cats. Not a likely suspect, thought the psychiatrist. But we shall see.

The captain continued crisply. "As our third day on the planet opens, each of you has had an opportunity to gather information in his or her specific field. We must now pool that knowledge and use it in our further decisions. Dr. Salter, as our environmentalist, we'll start with you."

"Right." Paul Salter squinted at them, as though searching mentally for the perfect balance between people, trees, oil refineries, waterfalls. A good man, thought Virginia. He continued. "Well, we have completed a comprehensive satellite survey of the surface of the planet, resolution one-centimeter. The entire surface appears to be one hundred percent silica sand. No sign of life, past or present, was detected. We speculate that the planet was once heavily cratered, much like Luna or Mercury. However, the driving sandstorms must have worn away any prominent surface features millions of years ago. We don't consider the winds to be a real problem. We could probably control them with windbreaks, just as we do today on various parts of Terra. Also, the winds would be a great source of energy, along with solar power. I'll give that one to Ben."

"Solar power—yes, plenty of that," said Dr. Rulain. "Owing to the binary star system, the planet has a complete night side only when the red star lines up with

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the blue. Must be quite a sight. Certain adaptations might be required. Right now Navetta is leaving the red sun—the cool one, relatively speaking—and heading toward the hot companion. Temperature at our equator while close to Mr. Red is five to ten Celsius. When we reach apogee we'll be only about a hundred twenty million miles from Mr. Torrid, and you can add thirty to that. Cold, then hot, then cold, and so on. Water? Back to you, Paul."

"Probably rarely rains on Navetta, but we could pipe water in from the seas. It would be supersaturated with silica, SiO_2, and the colonists would have to filter it. Still, they could probably adapt."

Spask nodded. "Thank you, Dr. Salter. Now, let's look at microbiology. Dr. Leifsdotter?"

"Presently indeterminate," said the microbiologist. "We used standard procedures. We put a fertile nutrient culture of cyanobacteria in a liter of sterile Navetta seawater. This—"

Spask interrupted her. "Excuse me, doctor, for the record, and for the benefit of some of us less well-informed, I wonder if you could provide some background before you go into the actual details?"

Probably meaning me . . . and yourself, thought Virginia. A good idea.

"Oh, sure," said the woman scientist. "Well, to put this in perspective, first let me review a bit of Earth history. The first life-form that did us any direct benefit was cyanobacteria—'c.b.' It came on stage about 3.5 billion years ago, when our atmosphere was mostly carbon dioxide and nitrogen, our day was only eighteen hours long, and our sun had only about seventy percent of its present radiation.

"Actually, cyanobacteria evolved from an even more archaic form of primitive one-celled life—green sulfur bacteria. That little fellow had something new and strange within its cell walls: a thing we call a chloroplast—an arrangement of molecules that let it use photons from the sun to help it strip hydrogen from H_2S, leaving elemental sulfur. Quite useful if you need to get rid of H_2S. But hydrogen sulfide is not our present problem—it's CO_2.

"So we move on to cyanobacteria. Well, little c.b. has its own special chloroplast, and back on Terra it used solar energy to change carbon dioxide into carbohydrate and make oxygen as a byproduct. And back in those early days on Terra it certainly had plenty of CO_2 to eat, so it multiplied exponentially and immediately spread over our planet, which at the time was mostly ocean, with lots of archipelagoes. It soon saturated the oceans with its byproduct oxygen, and that oxygen right away combined with dissolved iron to make iron oxide—iron ore. And when the iron was all precipitated, our little friend began spilling its oxygen into the atmosphere. You might have thought its cousins in the microbe world, the archaea and thermophiles, would have been grateful. But no, they were not. Up until then they had led a blissful life in an oxygen-free world. To them, oxygen was actually a deadly poison. They dealt with the crisis in different ways. Some mutated and made drastic genetic changes so they could live in oxygen. Some—the newly evolved aerobes—actually grew to love it, they couldn't live without it. Others—the anaerobes—sank into the ocean depths where there was no lethal oxygen. The rest simply died."

She stopped, took a deep breath, fanned herself with a notepad. They waited. She took another breath. "Well, before you know it, c.b. and its aunts and uncles and cousins evolved into other oxygen-producers—algae, seaweed, and so on. And it didn't take long then for these to crawl out of the water, first onto the beaches, then actually up onto dry land, where they became plants and trees and grass and flowers, and continued to convert carbon dioxide into carbohydrates and oxygen at a great rate. By the time our vertebrate ancestors scrambled

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out of the mud, the atmosphere was ready for them. Plenty of oxygen to breathe, not much CO_2." She paused and looked across the table at the psychiatrist, who gave her an encouraging smile.

The scientist continued. "So, to terraform a CO_2 planet, we start with cyanobacteria. First, we mutate the little bug, so it can trade genes within the bacteria community, genes that will help it survive and evolve and get ahead in the microbial world. And yesterday we put nutrient cultures of mutated cyanobacteria in ten separate liters of otherwise lifeless Navetta seawater. All were exposed to ambient local conditions. We cultured these mixtures for twenty-four hours." She paused, looked around the table. "Two things happened."

Virginia found herself leaning forward and listening intently.

"All c.b.'s had disappeared," said the microbiologist. "Not even a few tiny corpses left floating around. Zero. The other thing—I have some slides—Paul, if you could get the light?"

The environmentalist reached around behind him and snapped the switch. All faces turned toward the screen across the room.

"A *ladder?* " someone said softly.

Another: "Helga, what *is* it?"

"We found it in all ten cultures," she said. "Magnification, for comparison here's our own helical DNA. About the same cross-sectional diameter."

"Does it replicate?" asked Salter.

"We found no evidence of replication," she said. "What it *did*, it dismantled the cellular components of our cyanobacteria and reassembled them into what you see here, except that in most places where you'd look for carbon, you see silicon. It chewed up our DNA and used it to make this siliceous stuff. This *ladder* is actually over fifty percent silicon."

"Silicon? From where?" asked Karos. "The sandstorm?"

"No, we protected the cultures from incoming solids. Nothing from outside. The silica was in the seawater. As orthosilicic acid, of course. Silica as SiO_2 is practically insoluble."

"And no oxygen produced, I suppose?" asked Spask.

"Not a trace. Not in the water, not in the supernatant gases. It made these microladders, just the frames, and there it quit." Ms Leifsdotter turned off the projector and signalled for the lights. "And that finishes my report."

"Maybe the ladders didn't grow further because they ran out of food," Salter suggested.

"No, Paul, there's plenty of SiO_2 and nitrogen, phosphorus, sulfur still there. Maybe the ladders are trying to tell us something, but I'm not sure what."

And not you, Helga, earth-mother, thought Virginia. You're swamped with life. You're no Doomer. Live forever!

Spask broke in. "Well, that wraps it up. We can't terraform this planet. No reason to hang around. Let's get out of here. Mr. Jones, will you please sterilize the cultures and plant the Sagan plaque, and Mr. Easley, will you and Mr. Karos set the coords for home."

There was a brief dead silence.

"Captain," Dr. Rulain said quietly, "perhaps we should discuss this further."

"But Leifsdotter admits she *failed*," Spask said in harsh monosyllables. We—oh well . . . what?"

"Thank you, Captain," the heliologist said smoothly. "I think we should try one more thing. Maybe the ladders didn't grow further because they need a good dose of uv. By twelve hundred tomorrow Navetta will be facing the full glare of the blue sun, where the surface temperature reaches 9,700 degrees Kelvin and solar radiation will be loaded with high-energy ultraviolet, a hundred to four hundred nanometers. Helga, I suggest that you use these same ten cultures, microladders and all. This time, let the rays shine directly into the vessels, open, of course, but with Smith tubes to collect samples of any gases produced. Arrange electrostatic collectors to prevent entry of any blowing sand. Give it another twenty-four

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hours. What do you think?" He peered over at the microbiologist.

Dr. Leifsdotter chose her words carefully. "I think we'd be remiss in our duty to the Authority if we didn't try it." She looked directly at Spask. "Captain?"

It took him a moment. Then he spoke in a cold monotone. "Very well. Will you please make the arrangements. Call on the staff for whatever you need."

He refused to meet Virginia's eyes as they filed out.

Bob Easley was last to go. And it's not you, either, my young friend, thought Virginia. Death is not one of your esoteric dimensions. For you it doesn't exist at all.

"Some of you have seen some of this already," Dr. Leifsdotter said. "But I think I'm the only one who has seen it all. Ben, you were quite right to expose the specimens to the blue sun. That's just what they needed." She pointed with the laser wand to an area on the screen. "Note that little orange blip in the ladder cells. That's a chloroplast, in false color for easier inspection. It's sort of like terrestrial chlorophyll in that it uses sunlight, actually high-energy uv from the blue sun here, to convert carbon dioxide." She pointed to the scene on the screen. "Let me get the magnification up. There, that's about thirty thousand. Now let's take a closer look at the ladders."

Virginia squinted. "Two ladders?"

"Yes, actually this time there are two ladders there, one on top of the other, and with the rungs filled in. Watch the action. See? They unfold vertically, side by side, then they split apart."

Like DNA unzipping and doubling, thought Virginia.

"Ah—replication?" said Dr. Salter.

"Exactly," said the microbiologist. "Keep watching. See? Now they're folding into cubes and octagons and miscellaneous polyhedra. They're building microstructures, which in turn divide again, and again."

"What's the time cycle per division?" asked Dr. Rulain.

"As long as there's food, about every twenty minutes. Much faster than mitosis as we know it. In this run, though, they had to stop building and go dormant, nothing more to eat."

Navigator Easley looked bewildered. "But how about messenger RNA? Ribosomes—to code for specific silica polymers—analogous to our polypeptides? And energy—what does it use instead of adenosine triphosphate—ATP?"

"It's all there," Dr. Leifsdotter reassured him. "It's just . . . *simpler*, with fewer steps. They do it *their* way. For energy they use sunlight—uv—from Mr. Blue Sun. Each little silica cell carries a chloroplast, which collects and stores energy, which it uses for all the needs of the cell, metabolism, reproduction, everything."

Spask snorted. "Are you trying to tell us your ladders are *alive?*"

The microbiologist turned and regarded him coolly. "Well, Captain, give me a definition of life that everybody here agrees on, and I'll try to answer your question."

"But—surely we know what *life* is . . . don't we?"

"Your ladders do seem to replicate," Virginia said.

"A virus will replicate if it finds the right host," objected Salter, "but we don't think of a virus as being alive. It's got to do more than replicate."

Tapeworms? Mistletoe? All parasites, thought Virginia. Are they alive?

Lieutenant Karos smiled. "A mule can't replicate. Alive?"

Virginia recalled a definition she had learned way back in pre-med: "A self-sustained chemical system capable of undergoing Darwinian evolution." But she thought it best not to interrupt the experts.

"This is a very interesting discussion," said Spask, "but we don't really seem to be going anywhere with it. Does it really mean anything?"

Dr. Rulain said, "I think Helga has more for us. Bottom line, Helga."

She said simply, "It converts carbon

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dioxide mostly to carbon *monoxide*, plus some byproduct oxygen."

"Good God," Spask muttered.

There was a long silence.

Lieutenant Karos said quietly, "Carbon *mono*xide? You're sure?"

The microbiologist shrugged. "Double and triple-checked, Roy. For each molecule of oxygen, you get two molecules of carbon monoxide. The energy requirement is fantastic, but there you are. Sorry."

"This is unacceptable," Spask said.

Virginia had a pretty good idea what was going on in his mind. She knew what he meant by "unacceptable." Failure of the mission did not bother him. *That* was acceptable. The thing that was *not* acceptable was life that was not life as Spask knew and understood it. For him she suspected it was a violation of reality too bizarre to contemplate. This simply could not be. And that was that. Except it wasn't.

"Maybe it's all moot at this point," said Lieutenant Karos. "Still, I'm curious. Dr. Leifsdotter, your ladder didn't replicate at all during your first culture period, and now suddenly during the second period, it goes off like a rocket. What happened?"

The woman scientist shrugged. "Ben? Your department?"

"With two suns," the heliologist said, "any life on Navetta would be subject to a strong seasonal rhythm—a hundred and twenty Earth days orbiting the cool infrared sun, then looping out toward the hot blue sun. Those are its planet's natural seasons. When the planet is cool, life exists but lies dormant, like perennials in the ground back home, waiting for spring. But when primitive life on Navetta encounters the high energy radiation of Mr. Blue, it wakes up. For four months it eats everything in sight, reproduces exponentially, and then heads on back into its cool orbit, where it hibernates until its next mad fling." He laughed, then shook his head. "Helga, those ladder-cells killed and ate all your cyanobacteria. Obviously these microladders are the only life-form that can prosper and mutate and evolve under these particular conditions."

". . . mutate? . . . *evolve?* " muttered Spask.

Like trilobites, dinosaurs, Neanderthals, us? wondered Virginia.

Spask shook his head. "Dr. Rulain, that's sheer speculation. But even if you're right, so what? I say we still follow the book—sterilize the cultures, plant our Sagan plaque, and get out of here. Carbon *mono*xide! For heaven's sake!" He held the Sagan plaque up and waved it around. "Here, I'm ready. I'll plant it myself, while you people are debating. I'll suit up and fix it to the top of that cliff!"

"Captain," said Dr. Salter calmly, "we will of course leave a Sagan plaque before we depart. It's nothing you need to attend to personally. As a matter of fact it can be done from the ship, automatically. But all in good time. For starters, since you have brought the subject up, and for the benefit of those who may not know the details—" he glanced briefly at Virginia "—a word about our Sagans.

"The first Sagan plaques were sent out over three hundred years ago, in the Pioneer spacecrafts. They were book-size gold-anodized aluminum plates, and they aimed at summarizing information about us. The first Sagans showed an adult male and female. The spacecraft is behind the man, so the retriever can judge how tall we are. The plate shows our sun, and the craft leaving the third planet. The center of the spidery rays shows our location with respect to a selection of pulsars. Recipients could not only locate us, but since pulsars slow down with time, they could also determine when the Pioneer was launched. We sent them out, like messages in bottles cast into the sea. They left our solar system—but where they went, and whether any life-form ever found them, we don't know. Anyhow, nowadays, when our probes land on a new planet, they leave a Sagan plate, preferably bonded to bedrock. It says, we were here, *Homo sapiens*. We came as

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friends. This is our calling card, our *carte de visite.*"

"So what?" muttered Spask. "What's the point?"

"We're coming to that," the environmentalist said. "First, though, a preliminary question. Helga, what's the earliest date we have for evidence of life on Earth?"

"Roughly four billion years ago."

"Primitive strands of RNA—barely able to replicate, but with the capacity to evolve?"

"A fair description."

"You wrote an article about it. You said, statistically speaking, even the most rudimentary forms of life could not have been expected to self-assemble from chance encounters of nucleides for another five hundred million years?"

"Well, sure. To make even the simplest life-form—archaea, maybe—you'd have to line up several million molecules of adenine, thymine, guanine, cytosine, all neatly attached to sugar phosphate backbones. All those building blocks were there, of course, everything you needed, a real messy soup, in a million warm tidal pools all over the planet, and given time, they were bound to come together in the right order, and life would pop out. Time. Starting with four billion years ago as Day Zero, we get one tenth of one percent probability for the emergence of life during the next million years. A billion years after Day Zero, fifty percent probablity that life would form. Ninety-nine percent probability after two billion. So what happened? Life happened within the first thousand years after Day Zero. The probability of life forming so early is one chance in three trillion. It's too low to register on the bell curve. Statistically it couldn't have happened, but it did. After that, everything fell into place. A mere one hundred thousand years after Day Zero, we find simple cells, genetic material and ribosomes, cytoplasm in a diversity of forms. On an island off Greenland we find sedimentary rocks 3.86 billion years old, containing complex cells. At 3.46 billion we find cyanobacteria . . . colonizing at a great rate in stromatolites . . . the whole shmear. Finally, us."

Spask sighed. "Again, so what?"

Salter smiled. "We move on, switch direction once more. I refer now to the famous metal plate fragment found in a dry river bed in the Australian bush about a hundred years ago. I assume we all recall that."

Helga Leifsdotter shrugged. "I saw it, touched it. Some claimed early aboriginal artifact. Some claimed it proved the blackfellows actually did some early work in metal."

"Quite improbable," said Dr. Salter. "It would be the only known instance in nearly twenty thousand years of their history. Could early Dutch explorers have brought it in?"

"Probability zero," muttered the microbiologist.

"Or maybe worse," Rulain said mildly. "It's not generally known, but that fragment is gold film, no longer bright and intact, and not all pure 197. It has some interesting isotopes, end products of radioactivity. The isotope mix proves the plate is four billion years old, plus or minus a few hundred thousand."

"I see, I see," Dr. Leifsdotter said thoughtfully. "I *think* I see. You think aliens visited our planet four billion years ago, dropped *their* calling card, then left?"

"Aliens?" Spask muttered. "Hogwash!"

"What were they like?" Bob Easley asked diffidently.

"No way to tell exactly," said Karos. "Obviously, with space travel, they must have been highly intelligent, technically very sophisticated."

"So why did they come to Earth?" asked Virginia. "What did we have of any interest to them?"

"Perhaps they were terraformers?" said Lieutenant Karos. "Same as us?"

"Interesting thought," said Dr. Rulain. "Let's look at that. They were there, they were checking out our planet as it existed four billion years ago. Could they—from the viewpoint of *their* needs, terraform

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it? Make it livable for *their* people? We didn't have two suns, and our very young sun was only seventy percent as bright as it is today. But it had a broad spectral band, with strong ultraviolet radiation and no ozone layer to block it. And the spectrum had plenty of infrared, if they could arrange a cool phase. And Terra's atmosphere was mostly carbon dioxide and nitrogen, which they figured their life-forms could convert to breathable monoxide. It was certainly worth a try. So they made tests. They tried to grow their own special life-forms. They seeded our warm tidal pools and lagoons with their own DNA equivalents. And—again we speculate—they made what to them must have been a surprising and very unpleasant discovery. The local chemical riff-raff—our soupy mix of adenosine, thymine, all that collection of purines and pyrimidines—were determined to defend their home turf. Under the stimulus of invasion they did something they had never done before. They formed up like a battalion of colonial dragoons and they slaughtered the alien seed-life. Everywhere that the visitors dropped specimens—and they may have made thousands of deposits—they found they were making deadly, hungry, replicating strands of RNA that snapped up their own seedlings like tasty *hors d'oeuvres*."

"Crazy!" snorted the captain in a penetrating whisper.

Rulain ignored him. "The aliens eventually took the hint. They bonded their 'Sagan' plate to a hilltop on an archipelago that eventually became Mt. Kosciuszko in Australia, and they left. But the RNA that they had initiated stayed behind. And it made DNA . . . which mutated . . . first into archaea, and then into cyanobacteria, and lately, into *Homo sapiens*."

Can it be true? thought Virginia. Are we—*Homo sapiens*—the product of an alien terraforming crew?

Spask answered as though he had heard the question. "Utter fantasy. I'm no expert, but I'm no fool, either. You're trying to tell us we are descended from life-forms created by aliens. That's silly!"

"No, I think it could be true," said Dr. Leifsdotter. "I saw something in a jewelry shop in Melbourne several years ago that might have been the other half of the Kosciuszko fragment. The billennia had tarnished it, but when you imagine them fitted together, you see something analogous to our Sagan: it showed *their* . . . ah . . . life-form and where *they* came from."

"'Life-form,' Helga?" said Dr. Salter. He added softly, "Were you about to say . . . *ladders?*"

The woman scientist smiled. "How about ladders plus a binary sun system, one hot, one cold."

"You mean it?" Karos said softly. "You could see that on the plate fragments?"

"Yes."

"Great jumping Jupiter!" said Bob Easley. "Are we sitting here on their home planet?"

"No way to know for sure," said the heliologist. "This is certainly not the only red-blue binary in the galaxy. They could have originated in another one, come here, found our Sagan plaque."

"I doubt it happened that way," Helga Leifsdotter said. "They wouldn't need to *come* here to find our plaque—they'd already *be* here, because we're going to leave our specimens, and they'll evolve."

"So Navetta is fine for them, but no good for us?" the young navigator said plaintively.

"That's the situation," the microbiologist said. "Their red-blue suns will always transform our nitrogenous DNA helices into their siliceous ladder-cells, along with copious carbon monoxide."

"It all comes together," said Karos. "They will eventually find our plaque, right here on their home planet, right where we are going to leave it. It tells them Terra's exact location in space. They go forth, looking for it. They land on Terra in our distant Precambrian, before there was any life anywhere there—just a soupy molecular mix in the warm tidal basins and lagoons. Our atmosphere

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then was a blend of carbon dioxide and nitrogen. They probably thought the seasons and the red and blue solar spectrum would let their ladder-cells convert the CO_2 to CO. But they got a nasty surprise: they got elemental oxygen, totally toxic to them."

"I'll buy that," the microbiologist said. "Their Sagan plaque shows what they evolved *from*—ours shows what we evolved into."

"So," said Bob Easley, "if we return here in four or five billion years, we'll find intelligent life?"

"If we should come back, yes," said Dr. Leifsdotter. "But we won't come back, of course. The human race will be long gone—or dead. In fact by then the ladder people may be the only life-form remaining in this sector of the universe."

"Now wait just a minute," objected Spask. "This is gross insanity! Are you saying, five billion years from now intelligent aliens journey from this planet—*this planet, Navetta*—to Earth's distant past? What utter nonsense!"

"It's inherent in the Jaquino time-slip, Captain," said Easley. The young navigator wet his lips. "I can show you the math—"

"No!" the captain declared. "It just can't be! In five billion years these stars will be dead cinders!"

"Five billion years *is* a long time," said Dr. Rulain. "On the other hand, we face the high probability that these stars lasted long enough for these ladder seedlings to evolve into intelligent creatures—creatures who made a ship and visited Terra in our distant pre-life past. And we know what they did there, and what happened afterward. We know, because here we are."

Spask stared at him. His jaws moved, as though he were chewing and digesting what he had heard. "They made us, we turn around and make *them?* Do you people realize know what you are saying?" He looked around the table, wondering. "Well, I won't have it. We are *not* going to leave any ladder seedlings, nothing that could evolve into *them*. So forget it. Strictly against the rules. You know the protocol. In case of failure, sterilize everything, drop the plaque, get out."

Dr. Rulain said, "Captain, if life on earth had started five hundred million years later, as suggested by the laws of probability, Terra would just now be entering the Cambrian. Everything would have been set back by that delay of half a billion years. At that point in time all life was sea-borne, the land was still barren. No trees, no insects, no dinosaurs, no, not for another five hundred million years. The Yucatán meteorite that fell sixty-three million years ago wouldn't have killed any land life, because there wouldn't have been any land life, not yet, not for a long time. No, Captain, maybe the aliens didn't mean to do it, maybe it was all an accident, but I believe they did in fact start Earth-life. They did it a bit prematurely, actually half a billion years too soon in the statistical scheme of things. But here we are, talking about it, which we would not be if life had evolved on its own leisurely schedule. Destroy our specimens, Captain?" He folded his arms. "*Not* recommended!"

"Wait up, Ben," Virginia said. "Let me see if I understand this. You are saying that intelligent life eventually developed here on Navetta? Life that *we* planted?"

"Yes."

Her eyes narrowed. "And which then came to Earth and planted archaea that evolved into *us?*"

"In my humble opinion, yes again."

Salter, the environmentalist, shrugged. "But of course, there's no real proof either way."

"True, no *hard* proof," agreed Helga Leifsdotter. "Certainly no human eyewitnesses. But we do have the cold implacable laws of chance. And the alien plaque. And a fact: life emerged on Earth entirely too soon—by half a billion years. I believe we're looking at a strong probability."

"*How* strong?" asked Salter. He looked over at the navigator. "Bob? A little math here?"

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The young officer closed his eyes. His lips moved. Finally he blinked. "Based just on what you've given me, I'd estimate three to one, we made them, they made us."

"Ouch," somebody said softly.

"I don't get it," Spask said loudly. "What's going on?"

Virginia said, "Could I take that one? At least say what I understand the situation to be?"

"Please," said Spask.

"Well," the psychiatrist began hesitantly, "this is what I see as Bob's three-to-one probability. We drop our Sagan plaque, we pour these ten liters of micro-ladder specimens into the seas here on Navetta, and then we go home. The ladders multiply, evolve here, and finally, several billions of years later, they produce intelligent life—aliens. They find our plaque, they make a ship, take it through their own Jaquino *vermebuco*, and they come looking for Terra. They land on a barren planet. Their Jaquino time-warp puts them in Earth's distant pre-life past. They test Earth for colonizing possibilities—*terraforming*, if you will—but their ladder life won't grow, it all changes into our RNA. And so terrestrial life—*our* life—starts half a billion years earlier than it would have by Darwinian chance. And it's three to one that *they* did it."

"Well, so what," said Spask. "That's no reason to break the Rules, screw up the whole protocol. We'll all be in trouble I still say, drop the plaque, sterilize, get out!"

"Captain," Salter said slowly, "I'm not sure you understand. Here's the problem: if we sterilize those specimens, then, in that case, there is a high probability that life will never rise naturally here on Navetta, that a ship native to this planet will never visit Earth, that they will not start our terrestrial life system five hundred million years before it would be due to start normally, and that none of us here will ever come into existence."

As he listened, Captain Spask frowned. The furrows in his brow grew deeper as the seconds passed. Virginia Oxley watched the face of the officer turn various colors, first very red, then finally white.

He's got it, she thought. Somehow the man's reaction reminded her vaguely of a bit of history, quite possibly apocryphal: the untimely descent into madness of the Chinese savant Ching Lu, as reported by Marco Polo in the *Book*. Kublai Khan had ordered the scientist to determine which came first, the chicken or the egg, and not to eat, drink, or sleep until he could return with the answer.

She had a fair idea what was going on in Spask's head. They had forced him to think back, back, into far distant time where centuries became millennia and millennia faded into billennia. The perception of near-infinity was sudden, and it had hit the career man hard. She sympathized. Time vertigo could be a shock for the unprepared, like a neophyte mountain climber holding to the cliff face by his fingernails, knowing he must not look down, but he does look down.

We have come here, she thought. We have created ladder-forms that will evolve into Navetta aliens. They will go to Earth, create nucleotides that will evolve into us. We will come here, create ladder-forms that evolve into Navetta aliens. They will go to Earth . . . No beginning. No end. Just something that . . . *is*.

She suspected that this was not all that was bothering the officer. Spask knows that all this is being recorded in ship's log. If and when we get back it will be studied carefully by several groups, including the Admiralty Licensing Board. He knows if he doesn't follow the Rules it's quite possible he can never expect another berth, at least not as captain. Will *they* believe that we created the aliens, who then created us . . . ? So what is he going to do?

If he decides to sterilize, do we take the ship from him? Deposit the cultures anyway? Would that be mutiny? From the corner of her eye she glanced at the first officer. Well, well . . . Karos's face was a

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somber study; his arms were folded across his chest. The man was ready to take over—prevent Spask from destroying the cultures. Fine—that clears you, lieutenant. And *you're* clean, captain.

Which leaves . . . the second officer, Lieutenant Carl Jones. She forced herself not to look at him. She looked instead at the wall behind Spask, and there she visualized Escher's famous picture: "Drawing Hands"—two hands, each holding a pencil, each hand busily drawing the other. Possible only in a non-Euclidean world. She could well understand the captain's bafflement that had driven him to confiscate the masterpiece.

Bob Easley broke the silence. "And of course there's that other thing. . . ."

Virginia's eyes stabbed at him. "No, Bob."

He looked over at her in surprise. "Oh? Oh, sure, all right."

She had read the young mathematician clearly. He had been about to explain the corollary to the three-to-one theory: that the aliens must have held their own crucial conference in a ship on Terra some four billion years ago. That they had realized that they had evolved from seed left by the Sagan plate makers on Navetta, and that they knew that if they didn't seed Terra, they would vanish. She had cautioned silence because she didn't think Spask was ready for the corollary. He was having enough trouble with the main theorem.

She tried to visualize that critical alien conference. Did they have a microbiologist? Was she or he or it the first of their little group to say, "We must make *them* so they can make *us*." Did they argue? Was the decision a close call? What did they look like? She contrived a picture. How many of them? A head officer, a biologist, a chemist maybe, miscellaneous scientists? Perhaps a mathematician to guide them through the *vermebuco?* (What would *they* call it?) Would they, too have a shrink and a traitor? Did they wonder about us? She almost felt she knew them personally, as individuals. A strange sensation. But back to the *James Lovell.*

The Doom prophets, she mused, were only half right. True, the fate of humanity—past, present, future, is probably going to depend on what happens on the *Lovell,* and indeed probably in this very room and in the next few minutes. All because we are going to determine the fate of the Navetta people. And then there's the other side of the coin, unknown to the Doomers: the Navettans. Will they, or will they not, come into being, and if they do, will they save us? Yes, oh yes! Because here we are Meneer Escher, please observe. Our hands are busily drawing each other. We are bound together for eternity in a deadly symbiotic dance. One misstep, we all die.

It was funny, it was ridiculous, it was overwhelming. She wanted to laugh, but she was afraid, knowing it would come out as hysterical cackles. In a moment of curious self-observation she noted that her heart was pounding and that she had stopped breathing.

They waited in silence, watching the captain.

He looked slowly around the table. His face was cold stone. Finally he spoke, quietly, but with iron in his voice. "Mr. Jones, will you bring the ship back to the cliff top, and there plant the Sagan plaque securely." He turned to the microbiologist. "Meanwhile, Dr. Leifsdotter, will you formulate a suitable distribution pattern over the sea for the ten cultures. And Mr. Jones, after you plant the plaque, will you please move the ship over the pattern and assist Dr. Leifsdotter in depositing the cultures." He addressed the navigator. "Following that, Mr. Easley, will you please set a course for the *finestra*, and home."

Another silence.

"Sir," Lieutenant Jones ventured cautiously, "about the cultures . . . are we to . . . ah . . . enter that in the log?"

The captain scowled. "Absolutely. What a silly question." He looked around the table again, and his expression

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seemed to soften slightly. His eyes came to rest briefly on Virginia. "It was that time thing, wasn't it?"

"Yes, Captain."

"I'll be in my cabin." He took a deep breath, strode over to the door and disappeared into the corridor.

All those prophecies, she thought. Especially the one about the two hands. But how had the Doomers known? There was no way. Actually they were all just a a bunch of loonies, crying doom on general principle. Look at it scientifically. Did we in fact save humanity? Nobody will ever know for sure. Our continuing existence won't prove anything. The only way to prove the theory would be to prove *Homo sapiens* had never happened. In which case there would be nobody left to prove it *to*. Again she suppressed an urge to laugh.

Now, a matter of very high priority. The simple process of elimination had narrowed the Doomer suspect list down to Lieutenant Carl Jones. No surprise. But she still needed proof. And just now, it seemed to lie readily at hand. For the first time there was a good possibility of sabotaging the mission and fulfilling the prophecies. All he had to do was destroy the cultures. And maybe simultaneously vanish, but for a Doomer, that was probably not a deterrent. So where was the second officer?

Gone. As ordered, toward the bio bay and the cultures.

She felt in the pocket of her smock. Pen . . . mini notebook . . . A tiny vial. Nail polish remover? Should do nicely.

She slipped out quickly and followed the officer. He was still in the corridor. "Carl!"

He whirled, hesitated, then stood there, waiting for her.

She put a finger to her lips. When she had approached within arm's length, she looked back, then whispered: "*First, the dinosaurs.*"

He looked puzzled for a moment. "*You?*" Then, apparently satisfied, he responded in a low voice: "*Next, us.*"

She help up the vial. "Alkaline glutaraldehyde, mercury, arsenic base. Strongest known bactericide. A lot stronger than theirs. I can sterilize the ten cultures, and they'll never detect it, but you have to help."

He looked around. "Yes, of course."

"Leifsdotter is in there just now. All I need is ten seconds. Go in, tell her both of you need to talk to Bob Easley about the deposit pattern. While she's out I'll sterilize the cultures. When she returns, help her deposit all ten in your prearranged pattern. All very dead. Nobody will know. Just you and me."

He frowned. "You sure? *I* was just going to pour them down the drain."

"Wouldn't work. They'd simply make new cultures. And put you in irons. No, we play their game, make them *think* they're preserving humanity."

"Yes, you're right."

As he entered the bio bay she noted a tiny fleck of foam hanging in the corner of his lower lip.

She hurried away in the opposite direction. With a little practice, she thought, I could eventually make a pretty good liar.

And now, about the captain. There would be a Board hearing. His transgression lay not so much in violating a trivial housekeeping rule, but in his acceptance of a sequence of events as possibly true that the Licensing Board would view as utterly impossible. They will whisper to each other, is he mad? No liner for *you*, man. You'll be lucky to rate third mate on a moon tug. As he well knew.

Ah Fearless, she thought, whatever your lack of social skills, you've got guts. You are willing to go down with your ship. A real *mensch!* Well, for what it's worth, when you appear before that Board, we will all be there for you. Maybe even Carl Jones.

Meanwhile, I think I'll just drop by . . . retrieve my "Drawing Hands." We can explain Simultaneity to each other. Later, dance, maybe? You still have "Songe d'Automne." □

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James Van Pelt

ARK ASCENSION

Some of the most basic needs are among the least tangible.

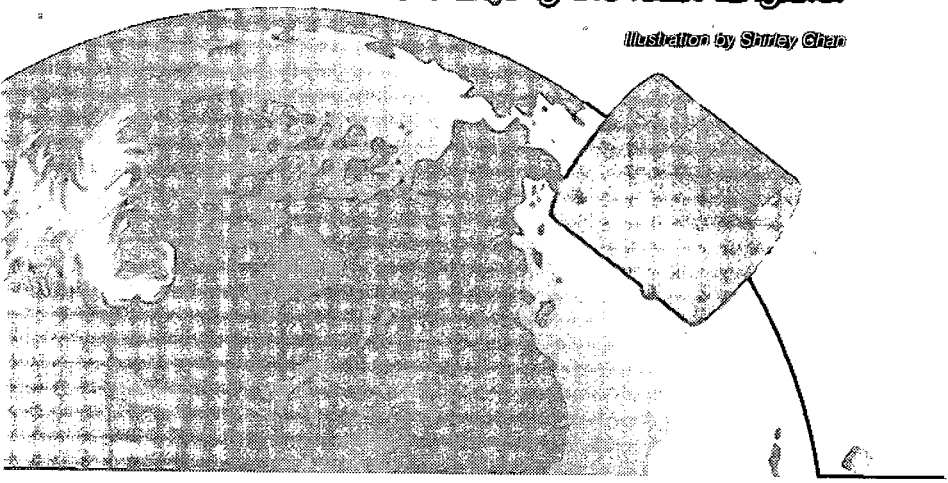

Illustration by Shirley Chan

Ark Ascension orbited hundreds of miles above the mutagen-infested Earth. Rotation created a one-grav interior in the seven-mile-long, seven-mile-diameter tube where genetically uncorrupted animals roamed 150 square miles of sculpted, planted and artificially lit landscape.

Martin tended the sun.

During the day he plotted ionization graphs, watched for ultraviolet and infrared variances, checked thermal output against projected goals and wrote a report about the largely automated processes. He checked the news one more time. The wolf had not whelped.

At dusk he left his east-end office where stars slowly revolved in one window and seven miles of bluffs, hills, and trees stood in the other. Pine smells and wet leaves met him. Gravelly dirt crunched beneath his shoes. The door's seams vanished into the wall. He took a deep breath and shivered.

The plasma sun dimmed in the west: an Ascension sunset. The sun didn't disappear below a horizon, but reached the end of its seven-mile trek, then faded as the gasses cooled. A mile above Martin, a hazy moon flickered on to start its night-long trip to the western end. He rubbed his upper arms, wishing he'd worn a coat.

He checked his wrist monitor linked to the plasma track and nodded. The moon produced no heat, but it lighted the interior which otherwise would be black as a cave, without a single star to break the inky tapestry.

To the north, a wolf howled. Martin tried to spot it. He wondered if it was the pregnant wolf's mate. The land sloped up both left and right, but the trees slanted with the slope until they appeared to be horizontal spikes poking from distant cliffs. Then the cliffs continued in a great arc, completing the world's roof above him. Beyond the moon in the clear evening air, he thought he saw movement. Deer,

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maybe, or elk; there was a small herd of each, but at this distance it was unlikely. Probably shifting shadows. Not the animals. He seldom saw them, although nearly a thousand roamed the artificial environment. A dozen biologists observed them, of course, and geneticists tested for mutagens, ever vigilant for contagion. Martin didn't see the scientists much. Their haunted faces and creepy depression bothered him. They acted as if the Earth had died. "Catastrophic species shift" they called it. Nothing remained the same, except here in Ark Ascension and the four other Arks just like it.

Martin avoided the crew, fifteen couples, twenty-three unmarried adults and thirteen children. He spent his time at the zero-*g* axis, fine-tuning the sun, tweaking magnetic containments, experimenting with plasma physics.

Sunset and moonrise brought him to the surface. A zoologist, Dr. Kette, the only single parent on board, and her daughter, Robyn, used this observation area too. The door's mechanical whisper behind told him they were there.

"It's cold, Mom," said Robyn, an eight-year-old whose rounded cheeks, dark eyes, and serious expression mirrored her mother's.

"Wintertime, dear. The animals and plants need the seasons to stay healthy."

Robyn leaned against her mother's leg. "It makes me sad. The trees are bare."

"Not the evergreens."

The sun's dull remnant winked out. Only the moon cast light, a cool, silvered sheen that shimmered the grass. Martin took a few steps away from the wall. If he didn't look up, the illusion nearly fooled him, a full moon on foothills. In the hollows, fog eddied and the temperature dropped. Frost would soon coat rock and branch, bush and earth.

"Can't you make the sun warmer, Martin?" said Robyn. "Can't we always have summer?"

Surprised that she'd spoken to him—generally their evening pilgrimages were silent—he said, "Most of the heat comes from the ground. . . ."

"As I've explained," said Dr. Kette. She sounded sad too. Martin knew that like the other women she wanted to have more children, but the mutagen hadn't been identified. No one knew if her babies would be born human. She didn't know if she'd been isolated in time.

"There's no snow," said Robyn. "How can we have winter without snow?"

"We're in a spacecraft. It can't snow here. We'll still have Christmas though. We'll decorate the apartment." Dr. Kette didn't sound convinced "We don't need snow for Christmas."

Robyn stamped her foot. It was half-hearted. Martin knew she couldn't really throw a tantrum. She was too nice a child for that.

"We can't even put up colored lights! Four days until Christmas! No snow and no lights." Robyn's tears were real.

Dr. Kette sat on the ground beside her. "I miss them, too."

Embarrassed, Martin moved further away. He'd never had a family. Too much lab time. But the image of Robyn leaning against her mother affected him. He wanted to hold her, to tell her it would be all right. Dr. Kette cried also. Mother and child displaced, no different from the animals wandering beyond.

After a bit, Martin approached, touched Dr. Kette on the shoulder. "You guys will freeze if you stay out here."

The woman looked up at him. "We really are a long, long way from home."

Martin couldn't do anything about snow. At 5,800 feet to the Ark's center, there wasn't air enough for clouds. Winter ground fog was common though. In the fall and spring, when the transition between the day's heat, the night's temperature drop and the humidity was just right, it drizzled for a few minutes in the morning, but no snow. He thought about Robyn crying.

A crew meeting the next morning dis-

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cussed the upcoming holiday. A party was proposed. Debate followed, a dispirited affair. The head of research argued, "Even if we are in exile, we can celebrate—we need a celebration."

"What is there to be joyful about?" countered Dr. Roam, the head of the medical unit, his lab coat meticulously pressed, his hair combed straight back and tight against his head, like a helmet. "It's ghoulish for us to be merry while our families on Earth struggle."

Martin sat in the back of the conference room. He thought about the deterioration of the news. Before they'd left, the worst of the mutagen births clustered in pockets. California suffered, as did Canada's western coast and Alaska. Martin had heard stories of monstrous polar bear cubs, mewling in the snow, hairless, deformed, abandoned by their mothers. The Midwest and the east were untouched. So the pattern continued the world over: some areas hit hard, others not. The mutagen spread slowly; it had taken twenty years to get this far. For twelve years the Arks were built, and then, a year ago January, were populated with animals and crew from uncontaminated areas. The crew came from areas with no unnatural births.

As if the Arks' occupation were a signal, the mutagen's progress accelerated. No place was untouched. From the Ark they watched the fear rise. It built. Cities burned, and there were no uncorrupted births. Fish or fowl, beast or man, the babies were not right. Most died, but more horribly, some lived. The crew could hardly bear to look at the pictures.

Against the back wall, the children sat. Maybe they are the last young ones we'll see, thought Martin. Maybe they're the end.

Someone said, "The animals are sterile. Even the rabbits have had no litters. Not even lab mice. We haven't saved anything by coming here. We should be in fully equipped laboratories searching for a cure. Running away solved nothing."

People muttered, while the captain waited for new comments.

Dr. Kette said, "We expected most animals would lose a breeding season. That's a well-documented effect of dislocation. It's too soon to tell, and there is the wolf. She should deliver soon."

Dr. Roam said, "Wolf pups would prove nothing. Even if they're good, it's only a matter of time before the mutagen breaks out here too."

"We don't know that," offered Dr. Kette.

"Yes you do!" thundered Roam. "The women know. We have been here eleven months, and there are twenty-seven women among us. Not one pregnancy. The women know we have no reason to celebrate."

Martin glanced again at the children. Robyn sat near the door, holding a crumpled drawing. A part of it showed through, a Christmas tree with ornaments and lights. As the argument grew, she twisted the paper tight. Her eyes were red, but she never cried. She looked lost.

In the end, they voted for no official celebration.

Later, in his zero-*g* work station, Martin adjusted the magnetic fields holding the ionized gasses in place. The biologists suggested the animals might feel more at home if the moon waxed and waned distinctly. He set the monthly cycle according to their numbers.

When finished, he contemplated the length of the Ark. In the middle, the sun glared, intolerably bright, nearly a third of its daily distance across the sky. Around it, trees pointed toward the axis; cliffs, hills, bluffs, stretches of meadow, streams (water pumped from the lakes at their bottoms to springs at their tops) surrounded the light. An unbroken landscape, a whole one—no horizon separating any one part from another. He found this image comforting, a perfect metaphor for life's unity, and he couldn't feel Dr. Roam's despair, or any of the others'. Thinking of the children, Martin

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wrote invitations to a Christmas party at sunset, Christmas Eve. He set the place, the central-Ark observation area, then sent them. He turned back to his equipment. There was work to be done; he had a party to prepare.

Martin arrived early, an hour before sunset. He took a tube transport that traveled on the Ark's outside. An elevator carried him and the supplies to a flat, sandy clearing overlooking a small cirque. At the hollow's bottom a lake reflected darkly. A startled mountain goat scrambled from the water's edge, tumbling small rocks as it leaped to the top. Most splashed through thin ice into the lake, and the goat disappeared into a boulder field.

He'd pressed the kitchen to make candy canes, and hung them from leafless bushes surrounding the clearing. As he hung the last one, the early guests stepped out of the elevator.

Four-year-old Elise, the youngest child aboard, found the first candy. She held the cane out for everyone to see, and soon the other children busied themselves finding more of the sweets, even the Nguyen twins, who were thirteen. Talk was muted. Almost mournful. Martin remembered Dr. Roam's pronouncement, "We have no reason to celebrate." The adults clustered around the radiant heaters, warming their hands. Robyn solemnly poked through brittle branches, looking for the last of the candy.

Martin crouched beside her. "Where's your mom?"

Robyn tucked a cane into her shirt pocket. She looked down, scuffing dirt with the toe of her shoe. "She went to see the wolves. She's been gone all day. I told her it was Christmas Eve, but she had to work."

"Ah, that's too bad." Martin gave her another candy cane from the extras he kept in a pouch. She added it to her collection.

"Thank you. I'll save them until later."

"There's hot chocolate in the thermoses," he said.

Robyn sighed and headed for the crowd. Now that the candy had been found, all stood near the heaters.

Hilliert, an older biologist called his son, Brad. "We really have to go, Martin. This was nice of you, but I don't think we're in the spirit." Other scientists nodded their heads. "It's cold, and we ought to get the kids home."

Martin glanced at the sun. It had reached the western wall and begun its dimming cycle. Chill stung his cheeks. "I have a surprise, but we have to wait a few minutes. There's a thermos with hot chocolate that's mostly rum in my bag over there, if you want to break that out."

Hilliert raised his eyebrows and put his hand on his son's head. "We'll stay a bit longer, Brad. Maybe we could sing a carol."

Gradually the sun faded out. Long shadows became less and less distinct, and soon the only light came from the heaters glowing orange in the clearing's middle. Martin stood behind the circle of parents and children, hands thrust deep into his pockets. Robyn tucked her hands into her armpits and didn't join the singing. They finished two verses of "Good King Wenceslas" before someone said, "It's pretty darned dark out here, Martin. Where's the moon?"

He checked his wrist monitor. A counter clicked to zero. To the east, a point of red light appeared. "What is that?" the same voice asked.

Martin turned. At the west end, a green light flickered on. The scientists and their children turned from the heaters and looked up. The first two lights floated quickly to the center of the sky to stop a few degrees apart like a red and green star. Then new lights appeared at each end, a blue one to the east, and an orange to the west. Soon, a line of colored points reached from end to end, much smaller than the moon or sun, not nearly as bright. Martin barely made out his own hands in the diffuse light, and then, following the program

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he designed, they began to pulse individually from bright to dark and back again.

The elevator door opened, its white light silhouetting Dr. Kette as she stepped out. Robyn cried out, "Mom, look. Christmas lights!" The door closed, and only the colored lights illuminated the world.

A hand touched his leg. "Is that you, Martin?" Robyn said.

"Yes."

"Mommy came. She came to your party."

Vaguely Martin could make out Dr. Kette standing beside him; he mostly saw the colors in her eyes as she looked up.

"This is lovely, Martin"

They stood for a long time. Behind them one of the kids said, "Let's sing 'Silent Night,'" and they did; their voices filled the clearing.

"Did you see the wolves?" asked Martin.

"Yes," said Dr. Kette. She held her daughter's hand. Their breath steamed in the frigid air. "The mother whelped," she said. "Four perfect pups. They were mutagen free."

Martin couldn't tell if she was crying.

In the darkness in the sky beyond, he saw glitters like stars, and realized the icy ponds and streams on the roof of the world reflected the display. It was an effect he'd never seen. The moon didn't reflect this way. In the day the sun revealed land and vegetation, but in this light, there were sparkles, red ones and green, blue and orange. Multicolored tinsel strings; long, glass-blue lines shading into the orange of frozen creeks; red fog rising into green, rising into blue; green snowy meadows blushing red then yellow; orange mountain ridges transformed; star glisters blinking everywhere—a thousand stars over Bethlehem—shards of Christmas light, changing in the changing night.

The wolves were born whole.

He'd never seen the Ark so beautiful. ■

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Harry Turtledove

TWENTY-ONE, COUNTING UP

The problem with trying to use your superior knowledge to shape somebody else's life is that he may have the same idea.

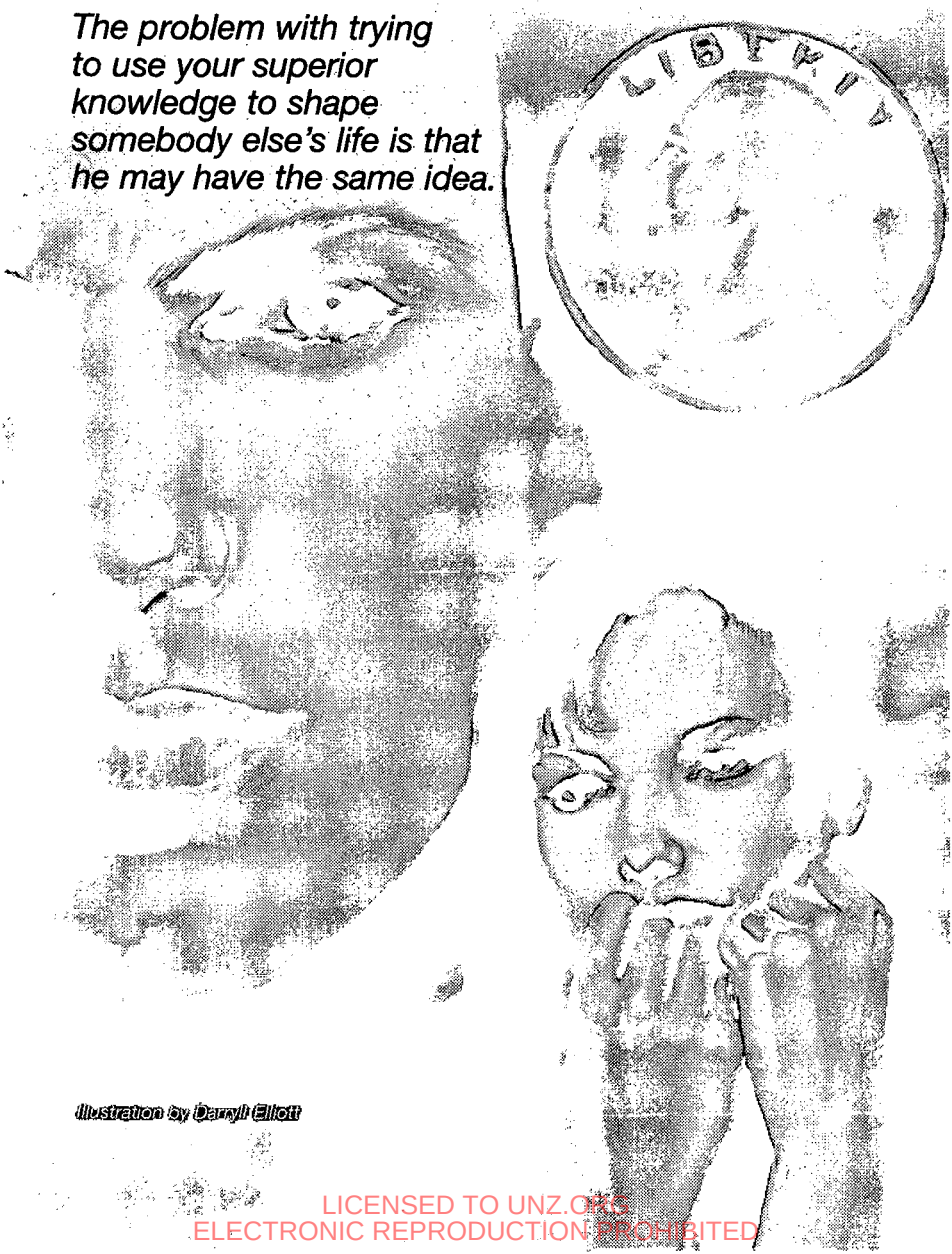

Illustration by Darryl Elliott

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Justin Kloster looked from his blue book to his watch and back again. He muttered under his breath. Around him, a hundred more people in the American history class were looking at their watches, too. Fifteen minutes left. After that, another breadth requirement behind him. His junior year behind him, too. Three down, one to go.

At precisely four o'clock, the professor said, "Time! Bring your blue books up to the front of the lecture hall."

Like everybody else, Justin squeezed out another couple of sentences before doing as he was told. He wrung his hand to show writer's cramp, then stuck the pen in the pocket of his jeans and headed for the door.

"How do you think you did?" somebody asked him.

"I'm pretty sure I got a B, anyhow," he answered. "That's all I really need. It's not like it's my major or anything." The prof could hear him, but he didn't much care. This wasn't a course for history majors, not that Cal State Northridge had many of those. It was a school for training computer people like him, business types, and teachers. After a moment, he thought to ask, "How about you?"

"Probably about the same," the other fellow said. "Well, have a good summer."

"Yeah, you, too." Justin opened the door and stepped from air conditioning and pale fluorescent light into the brassy sun and heat of the San Fernando Valley. He blinked a couple of times as his eyes adapted. Sweat started pouring off him. He hurried across campus to the parking lot where his Toyota waited. He was very blond and very fair, and sunburned if you looked at him sideways. He was also a little—only a little—on the round side, which made him sweat even more.

When he unlocked the car, he fanned the door back and forth a couple of times to get rid of the furnacelike air inside. He cranked the AC as soon as he started the motor. After he'd gone a couple of blocks, it started doing some good. He'd just got comfortable when he pulled into the gated driveway of his apartment building.

The Acapulco was like a million others in Los Angeles, with a below-ground parking lot and two stories of apartments built above it around a courtyard that held a swimming pool, a rec room, and a couple of flower beds whose plants kept dying.

The key that opened the security gate also opened the door between the lot and the lobby. Justin checked his snail-mail and found, as he'd hoped, a check from his father and another from his mother. His lip curled as he scooped the envelopes from his little mailbox. His folks had gone through a messy divorce his senior year in high school. These days, his father was living with a red-headed woman only a couple of years older than he was—and his mother was living with a dark-haired woman only a couple of years older than he was. They both sent money to help keep him in his apartment . . . and so they wouldn't have to have anything more to do with him. That suited him fine. He didn't want to have anything to do with them these days, either.

He used the security key again to get from the lobby to the courtyard behind it, then walked back to his apartment, which wasn't far from the rec room. That had worried him when he first rented the place, but hardly anybody played table tennis or shot pool or lifted weights, so noise wasn't a problem.

His apartment was no neater than it had to be. His history text and lecture notes covered the kitchen table. He chuckled as he shoved them aside. "No more pencils, no more books, no more teachers' dirty looks," he chanted—and how long had people escaping from school been singing that song? He grabbed a Coke from the refrigerator and started to sit down in front of the space he'd cleared. Then he shook his head and carried the soda back into the bedroom instead.

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He really lived there. His iMac sat on a desk in a corner by the closet. Justin grinned when he booted it up. It didn't look like all the boring beige boxes other companies made. As soon as the desktop came up, he logged onto Earthlink to check his e-mail and see what was going on in some of the newsgroups he read.

None of the e-mail was urgent, or even very interesting. The newsgroups . . . "How about that?" he said a couple of minutes later. Dave and Tabitha, who'd both been posting in the Trash Can Sinatras newsgroup for as long as he'd been reading it, announced they were getting married. Justin sent congratulations. He hoped they'd get on better than his own folks had. His girlfriend's parents were still together, and still seemed to like each other pretty well.

Thinking of Megan made him want to talk to her. He logged off Earthlink—having only one line in the apartment was a pain—and went over to the phone on the nightstand. He dialed and listened to it ring, once, twice . . . "Hello?" she said.

"What's the story, morning glory?" Justin said—Megan was wild for Oasis. He liked British pop, too, though he preferred Pulp, as someone of his parents' generation might have liked the Stones more than the Beatles.

"Oh. Hiya, Justin." He heard the smile in her voice once she recognized his. He smiled, too. With exams over for another semester, with his girlfriend glad to hear from him, the world looked like a pretty good place. Megan asked, "How'd your final go?"

"Whatever," he answered. "I don't think it's an A, but I'm pretty sure it's a B, and that's good enough. Want to go out tonight and party?"

"I can't," Megan told him. "I've got my English lit final tomorrow, remember?"

"Oh, yeah. That's right." Justin hadn't remembered till she reminded him. "I bet you're glad to get through with most of that lower-division stuff." She was a year behind him.

"This wasn't so bad." Megan spoke as if telling a dark, shameful secret: "I kind of like Shakespeare."

"Whatever," Justin said again. All he remember from his literature course was that he'd been damn lucky to escape with a B-minus. "I'll take you to Sierra's. We can get margaritas. How's that?"

"The bomb," Megan said solemnly. "What time?"

"How about six-thirty? I start at CompUSA tomorrow, and I'll get off a little past five."

"Okay, see you then," Megan said. "I've got to get back to *Macbeth*. 'Bye." She hung up.

Justin put *This Is Hardcore*, his favorite Pulp album, in the CD player and pulled dinner out of the freezer at random. When he saw what he had, he put it back and got another one: if he was going to Sierra's tomorrow night, he didn't want Mexican food tonight, too. Plain old fried chicken would do the job well enough. He nuked it, washed it down with another Coke, then threw the tray and the can into the trash and the silverware into the dishwasher. When he started running out of forks, he'd get everything clean at once.

He went back into the bedroom, surfed the Net without much aim for a while, and then went over to bungie.com and got into a multiplayer game of Myth II. His side took gas; one of the guys didn't want to follow their captain's orders, even though his own ideas were a long way from brilliant. Justin logged off in disgust. He fired up his Carmageddon CD-ROM and happily ran down little old ladies in walkers till he noticed in some surprise that it was after eleven. "Work tomorrow," he sighed, and shut down and went to bed.

Freshly showered, freshly shaved, a gold stud in his left ear, he drove over to Megan's parents' house to pick her up. Her mother let him in. "How are you, Justin?" she said. "How do you like your new job?"

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"I'm fine, Mrs. Tricoupis," he answered. "The job's—okay, I guess." One day had been plenty to convince him his supervisor was a doofus. The guy didn't know much about computers, and, because he was pushing thirty, he thought he could lord it over Justin and the other younger people at the store.

Megan's mom caught Justin's tone. Laughing, she said, "Welcome to the real world." She turned and called toward the back of the house: "Sweetie! Justin's here!"

"I'm *com*ing," Megan said. She hurried into the living room. She was a slim, almost skinny brunette with more energy than she sometimes knew what to do with. "Hiya," she told Justin. The way she looked at him, she might have invented him.

"Hi." Justin felt the same way about her. He wanted to grab her right then and there. If her mother hadn't been standing three feet away, he would have done it.

Mrs. Tricoupis laughed again, on a different note. It didn't occur to Justin that she could see through Megan and him. She said, "Go on, kids. Have fun. Drive carefully, Justin."

"Whatever," Justin said, which made Megan's mom roll her eyes up to the heavens. But he'd been in only one wreck since getting his license, and that one hadn't quite been his fault, so he couldn't see why she was ragging on him.

He didn't grab Megan when they got into the car, either. At the first red light, though, they leaned toward each other and into a long, wet kiss that lasted till the light turned green and even longer—till, in fact, the old fart in the SUV behind them leaned on his horn and made them both jump.

Sierra's had stood at the corner of Vanowen and Canoga for more than forty years, which made it a Valley institution. They both ordered margaritas as they were seated, Megan's strawberry, Justin's plain. The waiter nodded to her but told Justin, "I'm sorry, *señor*, but I'll need some ID."

"Okay." Justin displayed his driver's license, which showed he'd been born in April 1978, and so had been legal for a couple of months.

"*Gracias, señor*," the waiter said. "I'll get you both your drinks." Justin and Megan didn't start quietly giggling till he was gone. Megan was only twenty, but people always carded Justin.

The margaritas were good. After a couple of sips of hers, Megan said, "You didn't even ask me how I did on my final."

"Duh!" Justin hit himself in the forehead with the heel of his hand. "How *did* you do?"

"Great," she said happily. "I think I might even have gotten an A."

"That rocks." Justin made silent clapping motions. Megan took a seated bow. He went on, "How do you feel like celebrating?"

"Well, we probably ought to save club-hopping for the weekend, since you've got to go to work in the morning." Megan stuck out her tongue at him. "See? *I* think about what's going on with *you*." Justin started to get chuffed, but didn't let it show. A couple of seconds later, he was glad he didn't, because Megan went on, "So why don't we just go back to your place after dinner?"

"Okay," he said, and hoped he didn't sound slaveringly eager. Maybe he did; Megan started laughing at him. But it wasn't mean laughter, and she didn't change what she'd said. He raised his margarita to his lips. At twenty-one, it's easy to think you've got the world by the tail.

He hardly noticed what he ordered. When the waiter brought it, he ate it. It was good; the food at Sierra's always was. Afterwards, he had to remember to stay somewhere close to the speed limit as he drove up Canoga toward the Acapulco. Getting a ticket would interrupt everything else he had in mind.

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When he opened the door to let Megan into his apartment, she said, "You're so lucky to have a place of your own."

"I guess so," Justin answered. He thought she was pretty lucky to have parents who cared enough about her to want her to stay at home while she went through college. As far as he was concerned, the checks his father and mother sent counted for a lot less than some real affection would have. He'd tried explaining that, but he'd seen it made no sense to her.

She bent down and went pawing through his CDs and put on *I've Seen Everything*, the Trash Can Sinatras' second album. As "Easy Road" started coming out of the stereo, she sighed. "They were *such* a good band. I wish they'd made more than three records before they broke up."

"Yeah," Justin said. However much he liked the Sinatras, though, he didn't pay that much attention to the music. Instead, he watched her straighten and get to her feet. He stepped forward to slip an arm around her waist.

She turned and smiled at him from a range of about six inches, as if she'd forgotten he was there and was glad to be reminded. "Hiya," she said brightly, and put her arms around him. Who kissed whom first was a matter of opinion. They went back into the bedroom together.

They'd been lovers for only a couple of months. Justin was still learning what Megan liked. He didn't quite get her where she was going before he rather suddenly arrived himself. "Sorry," he said as his heartrate slowed toward normal. "Wait a few minutes and we'll try it again." It was only a few minutes, too. At his age, he could—and did—take that for granted. After the second time, he asked, "Better?"

"Yeah," Megan answered in a breathy voice that meant it was quite a bit better. Or maybe that breathy voice meant something else altogether, for she was still using it as she went on, "Get up, will you? You're squashing me."

"Oh." Justin slid his weight—*too much weight*, he thought, not for the first time—off her. "I didn't mean to."

"A gentleman," she said darkly, "takes his weight on his elbows." But she laughed as she said it, so she couldn't have been really mad.

Justin scratched his stomach, which gave him an excuse to feel how too much of it there was. He wasn't really tubby. He'd never been really tubby. But he would never have six-pack abs, either. Twelve-pack or maybe a whole case, yeah. Six-pack? Real live muscles? Fuhgeddaboutit. Unlike some other girls he'd known, Megan had never given him a hard time about it.

"Shall we go down to the Probe Friday night?" he said. "They don't have me working Saturday, so we can close the place and see what kind of after-hours stuff we can dig up."

"All *right*," Megan said. She slid off the bed and went into the bathroom. When she came back, she started dressing. Justin had half hoped for a third round, but it wasn't urgent. He put his clothes on again, too.

The drive back to Megan's house passed in happy silence. Justin kept glancing over at her every so often. *I'm a pretty lucky fellow*, he thought, *finding a girl I can . . .* Then he clicked his tongue between his teeth. He didn't even want to think the word *love*. After he'd watched his parents' messy breakup, that word scared the hell out of him. But it kept coming back whether he wanted it to or not. He told himself that was a good sign, and came close to believing it.

The Probe lay a couple of blocks off Melrose, the heart of the L.A. scene. Justin snagged a parking space in front of a house not far away. Megan gave him a hand. "I thought we'd have to hike for, like, miles," she said.

"Well, we've got the shoes for it,"

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Justin said, which made her grin. They both wore knockoffs of Army boots, big and black and massive, with soles that looked as if they'd been cut from tractor tire treads. Justin made sure he put the Club on the steering wheel before he got out of the car. Things in this neighborhood had a way of walking with Jesus if you weren't careful.

He and Megan had no trouble snagging a table when they got inside the Probe. "Guard it with your life," he told her, and went over to the bar to buy a beer. He got carded again, and had to haul out his license. He brought the brew back to Megan, who couldn't pass the ID test, then got another one for himself.

They both eyed the deejay's booth, which was as yet uninhabited. "Who's it supposed to be tonight?" Megan asked. Before Justin could answer, she went on, "I hope it's Helen. She plays the best mix of anybody, and she's not afraid to spin things you don't hear every day."

"I dunno," Justin said. "I like Douglas better, I think. He won't scramble tempos the way Helen does sometimes. You can really dance when he's playing things."

Megan snorted. "Give me a break. I have to drag you out there half the time."

"Proves my point," Justin said. "I need all the help I can get."

"Well, maybe," Megan said: no small concession. She and Justin analyzed and second-guessed deejays the way football fans played Monday-morning quarterback. Their arguments got just as abstruse and sometimes just as heated, too. Megan didn't drop it cold here: she said, "As long as it's not Michael."

Justin crossed his forefingers, as if warding off a vampire. "Anybody but Michael," he agreed. "I don't know how they can keep using him. His list is so lame—my *father* would like most of it." He could find no stronger condemnation.

A couple of minutes later, a skinny redheaded guy with a buzz cut even shorter than Justin's, little tiny sunglasses, and a silver lip ring that glittered under the blazing spots sauntered across the stage to the booth. "It's Douglas," Megan said. She didn't sound too disappointed; she liked him next best after Helen.

"Yeah!" Justin let out a whoop and clapped till his hands hurt. A lot of people in the club were doing the same; Douglas had a considerable following. But there were also scattered boos, and even one raucous shout of, "We want Michael!" Justin and Megan looked at each other and both mouthed the same word: *losers*.

Douglas didn't waste time with chatter. That was another reason Justin liked him—he didn't come to the Probe for foreplay. As soon as the music started blaring out, an enormous grin spread over his face. He didn't even grumble when Megan sprang up, grabbed him, and hauled him out onto the floor. He gave it his best shot. With the bass thudding through him like the start of an earthquake, how could he do anything else?

Tomorrow, he knew, his ears would ring and buzz. His hearing wouldn't be quite right for a couple of days. But he'd worry about that later, if he worried at all. He was having a good time, and nothing else mattered.

Somewhere a little past midnight, a guy with a pierced tongue drifted through the crowd passing out fliers Xeroxed on poisonously pink paper. RAVE! was the headline in screamer type—and in a fancy font that was barely legible; Justin, who'd just taken a desktop-publishing course, would never have chosen it. Below, it gave an address a few blocks from the Probe and a smudgy map.

"Wanna go?" Justin asked when the thundering music stopped for a moment.

Megan tossed her head to flip back her hair, then wiped her sweaty fore-

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head with the sleeve of her tunic. "Sure!" she said.

After the Probe closed at two, people streamed out to their cars. The not-quite-legal after-hours action—at which Justin saw a lot of the same faces—was in an empty warehouse. He'd never been to this one before, but he'd been to others like it. Dancing till whenever was even more fun than dancing till two, and there was always the chance the cops would show up and run everybody out.

There were other ways to have fun at raves, too. A pretty blond girl carried an enormous purse full of plastic vials half full of orange fluid. "Liquid Happiness?" she asked when she came up to Justin and Megan.

They looked at each other. Justin pulled out ten bucks. The girl gave him two vials. She went on her way. He handed Megan a vial. They both pulled out the stoppers and drank. They both made faces, too. The stuff tasted foul. The drugs you got at raves usually did. Justin and Megan started dancing again, waiting for the Liquid Happiness to kick in.

As far as Justin was concerned, it might as well have been Liquid Wooziness. He felt as if his head were only loosely attached to the rest of him. It was fun. It would have been even more fun if he'd been more alert to what was going on.

Things broke up about a quarter to five. Justin's head and the rest of him seemed a little more connected. He didn't have too much trouble driving back to the Valley. "Take you home or go back to my place?" he asked Megan as he got off the Ventura Freeway and onto surface streets.

"Yours," Megan said at once. "We're so late now, another half hour, forty-five minutes won't matter at all."

He reached out and set his hand on her thigh. "I like the way you think."

His boss knew even less about Macs than he did about other computers. Since said boss was convinced he knew everything about everything, persuading him of that took all the tact Justin had, and maybe a little more besides. He got home from CompUSA feeling as if he'd gone through a car wash with his doors open.

As usual, he sorted through his snail-mail walking from the lobby to his apartment. As usual, the first thing he did when he got to the apartment was toss most of it in the trash. And, as usual, the first worthwhile thing he did was turn on his computer and check e-mail. That was more likely to be interesting than what he got from the post office.

At first, though, he didn't think it would be, not today. All he had were a couple of pieces of obvious spam and something from somebody he'd never heard of who used AOL. His lip curled. As far as he was concerned, AOL was for people who couldn't ride a bicycle without training wheels.

But, with nothing more interesting showing on the monitor, he opened the message. He didn't know what he'd been expecting. Whatever it was, it wasn't what he got. *Who but you*, the e-mail read, *would know that the first time you jacked off, you were looking at Miss March 1993, a little before your fifteenth birthday? Gorgeous blonde, wasn't she? The only way* I *know is that I am you, more or less. Let me hear from you.*

The signature line read, *Justin Kloster, age 40.*

Justin Kloster, age twenty-one, stared at that: stared and stared and stared. He remembered Miss March 1993 very, very well. He remembered sneaking her into the bathroom at his parents' house, back in the days before they'd decided to find themselves and lose him. He remembered not quite being sure what would happen as he fumbled with himself, and how much better reality had been than anything he'd imagined.

What he didn't remember was ever

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telling anybody about it. It wasn't the sort of thing you advertised, that was for damn sure. Could he have mentioned it when he was shooting the bull with his buds, maybe after they'd all had a few beers, or more than a few? He shook his head. No way.

He looked at the signature line again. *Justin Kloster, age 40*? "Bullshit," he muttered. He wasn't forty, thank God. Forty was the other side of the moon, the side old men lived on. Not really old, ancient, but old like his father. Old enough. The only thing that made the idea getting to forty even halfway appealing was that he might do it with Megan. After all, she'd only be thirty-nine then.

What to do about the message? He was tempted to delete it, forget it. But he couldn't, not quite. He chose the REPLY function and typed, *What kind of stupid joke is this? Whatever it is, it's not funny*. He thought about adding *Justin Kloster, age 21* to it, but he didn't want to acknowledge it even enough to parody. He sent the bald e-mail just the way it was.

He walked out to the kitchen and threw a Hungry Man dinner in the microwave. As soon as it started, he opened the refrigerator and dithered between Coke and a beer. He seldom drank alcohol when he was by himself. Today, he made an exception. He popped open a can of Coors Light and took a long pull. The beer slid down his throat, cold and welcome.

As if drawn by a magnet, he went back to the computer. He had no way of knowing when the smartass on AOL who signed himself with his own name would send more e-mail, or even if he'd send any more at all. But the fellow might—and Justin spent a lot of time online just about every evening anyhow.

Sure as hell, new e-mail from that same address came in before the microwave buzzed to tell him his dinner was done. He took another big swig of beer, then opened the mail.

No joke, it read. *Who else but you would know you lost your first baby tooth in a pear at school when you were in the first grade? Who else would know your dad fed you Rollos when he took you to work with him that day when you were eight or nine? Who else would know you spent most of the time while you were losing your cherry staring at the mole on the side of Lindsey Fletcher's neck? Me, that's who: you at 40. Justin Kloster.*

"Jesus!" Justin said hoarsely. His hands were shaking so much, the beer slopped and splashed inside the can. He had to put the can down on the desk, or he would have spilled beer on his pants.

Out in the kitchen, the microwave did let him know his dinner was ready. He heard it, but he hardly noticed. He couldn't take his eyes off the iMac's monitor. Nobody knew that stuff about him. *Nobody*. He would have bet money neither his mother nor his father could have told how he lost his first tooth, or when. He would have bet more money his dad couldn't have remembered those Rollos to save himself from a firing squad.

As for Lindsey Fletcher . . . "No way," he told the words, the impossible words, on the screen. Telling them that didn't make them go away. Lindsey was a cute little blonde he'd known in high school. They'd never even broken up, not in the sense of a fight or anything, but she'd moved out to Simi Valley with her folks the summer his parents' marriage struck a mine, and they'd stopped dating. A damn cute little blonde—but she did have that mole.

Justin went to the kitchen, opened up his dinner, and carried it and a couple of dish towels and (almost as an afterthought) a knife and fork back into the bedroom. He put the towels in his lap so the dinner tray wouldn't burn his legs and started to eat. He hardly noticed what he was shoveling into his face. *What do I say?* he kept wondering. *What the hell do I say?*

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That depended on what he believed. He didn't know what the hell to believe. "Time travel?" he said, and then shook his head. "Bullshit." But if it was bullshit, how did the guy sending him e-mail know so goddamn much? The truth, no doubt, was out there, but how could anybody go about getting his hands on it?

The line made him decide how to answer. *I don't watch* X-Files *much*, he typed, *but maybe I ought to. How could you know all that about me? I never told* anybody *about Lindsey Fletcher's neck.*

Whoever the other guy was, he answered in a hurry. Justin imagined him leaning toward his computer, waiting for AOL's stupid electronic voice to tell him, "You've got mail!" and then writing like a bastard. *How do I know?* he said. *I've told you twice now—I know because I am you, you in 2018. It's not* X-Files *stuff—it's good programming. Believe me, I'm back here for a good reason.*

"Believe you?" Justin yelped, as if the fellow sending him e-mail were there in the bedroom with him. "How am I supposed to believe you when you keep telling me shit like this?" His fingers said the same thing, only a little more politely. *But that's impossible*, he wrote, and sent the message.

Okay. The reply came back almost instantly. *But if it is impossible, how do I know all this stuff about you?*

That was a good question, what his grandfather called the sixty-four-dollar question. Justin would have been a lot happier had he had a sixty-four-dollar answer for it. Since he didn't, being flip would have to do. *I don't know*, he wrote. *How* do *you know all this stuff about me?*

Because it's stuff about me, too, said the fellow on the other end of the computer hookup. *You don't seem to be taking that seriously yet.*

Justin snorted. "Yeah, right," he said. "Like I'm supposed to take any of this crap seriously. Like anybody would." He snapped his fingers and laughed out loud. "I'll fix you, you son of a bitch. Hassle me, will you?" His fingers flew over the keyboard. *If you're supposed to be me, then you'll look like me, right?*

He laughed again. That'd shut Mr. Mindgames up, by God. Except it didn't. Again, the reply came back very fast. *Right*, wrote the stranger who claimed to be his older self. *Meet me in front of the B. Dalton's in the Northridge mall tomorrow night at 6:30 and I'll buy you dinner. You'll see for yourself.*

"Huh," Justin said. He hadn't expected to have his bluff called. He hadn't thought it was a bluff. He typed three defiant words—*See you there*—sent them off, and shut down his iMac. It was still early, but he'd had enough electronic weirdness for one night.

Like Topanga Plaza, the Northridge mall was one of Justin's favorite places. He'd spent a lot of time at both of them, shopping and killing things at the arcade (though Topanga, for some reason, didn't have one) and hanging out with his buds and just being by himself. He'd been especially glad of places to be by himself when his parents' marriage went south. Northridge had just reopened then, after staying shut for a year and a half after the big quake in '94. If they'd let him, he would have visited it while it was in ruins. Even that would have beat the warfare going on at his house.

He parked in the open lot on the south side of the mall, near the Sears. Everyone swore up and down that the new parking structures they'd built since the earthquake wouldn't come crashing down the way the old ones had. Maybe it was even true. Justin didn't care to find out by experiment.

His apartment was air-conditioned. His Toyota was air-conditioned. He worked up a good sweat walking a hundred feet from the car to the entrance under the Sears façade that was also

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new since the quake. Summer was here early this year, and felt ready to stay for a long time. *Global warming*, he thought. He opened the door. The mall, thank God, was also air-conditioned. He sighed with pleasure at escaping the Valley heat again.

He walked through the Sears toward the entryway into the rest of the mall. None of the men's clothing he passed looked interesting. Some of it was for businessmen—not particularly successful businessmen, or they wouldn't shop at Sears. The rest of the clothes were casual, but just as unexciting.

An escalator took Justin up to the second level. The B. Dalton's was on the right-hand side as he went north, not too far past the food court in the middle of the mall. He paused a couple of times to eye pretty girls sauntering past—yeah, he was seeing Megan all the time and happy about that, but it didn't mean he was blind. One of the girls smiled at him. He wasn't foolish enough to let himself get distracted. Not quite.

Past the food court, on toward the bookstore. A guy was leaning against the brushed-aluminum rail—a blond, slightly chunky guy in a black T-shirt, baggy jeans, and Army boots. He'd been looking the other way. Now he swung his head back toward Justin—and he had Justin's face.

Justin stopped in his tracks. He felt woozy, almost ready to pass out, as if he'd stood up too suddenly from a chair. He had to grab the rail himself, to keep from falling down. He didn't know what he'd expected. That the other guy's e-mail might be simple truth had never crossed his mind.

He wanted to get the hell out of there. His older self also looked a little green around the gills. And why not? He was meeting himself for the first time, too. Justin made himself keep going.

When he got up to himself-at-forty, his older self stuck out a hand and said, "Hi. Thanks for coming." His voice didn't sound the way Justin's did in his own ears, but it did sound the way he sounded when he got captured on videotape.

Both Justins looked down at the hands that matched so well. "Maybe I'm not crazy," Justin said slowly. "Maybe you're not crazy, either. You look just like me." He studied his older self. Despite the buzz cut that matched his own, despite the Cow Pi T-shirt, he thought himself-at-forty did look older. But he didn't look a lot older. He didn't look anywhere close to the age he was claiming.

"Funny how that works," his older self said with a tight smile.

He was sharper, more abrupt, than Justin. He acted like a goddamn adult, in other words. And, acting like an adult, as if he knew everything there was to know just because he had some years under his belt, he automatically ticked Justin off. Justin put his hands on his hips and said, "Prove you're from the future." Maybe this guy was a twin separated at birth. Maybe he was no relation, but a double anyhow. Maybe . . . Justin didn't know what.

His older self reached into the pocket of his jeans and pulled out a little blue plastic coin purse, the kind only a grownup would use. Squeezing it open, he took out a quarter. "Here—this is for you." He gave it to Justin.

It lay in Justin's hand eagle side up. Justin turned it over. It still looked like any other quarter . . . till he saw the date. He thought his eyes would bug out of his head. "It's from 2012," he whispered. "Jesus. You weren't kidding." Four little numbers stamped onto a coin, and the reality of what he'd just walked into hit him over the head like a club.

"I told you I wasn't." His older self sounded like an adult talking down to a kid. That helped convince him, too. Himself-at-forty continued, "Come on. What's the name of that Korean barbecue place over on Reseda?"

"The Pine Tree?" Justin said. He liked the restaurant. He'd taken Megan there once, and she'd liked it, too.

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"Yeah." Himself-at-forty sounded as if he'd needed reminding. Did that mean he didn't go there in 2018? Before the question could do anything more than cross Justin's mind, his older self went on, "Let's go over there. I'll buy you dinner, like I said in e-mail, and we can talk about things."

Justin was hungry—he usually ate dinner earlier—but that wasn't tops on his list. He came out with what was: "Like what you're doing here."

His older self nodded. "Yeah. Like what I'm doing here."

As often as not, Justin and whomever he was with turned out to be the only Caucasians in the Pine Tree. He and Megan had been. He and his older self were, too. The waitresses were all Korean; none of them spoke a whole lot of English.

Himself-at-forty ordered marinated beef and pork they could cook themselves at the gas grill set into the tabletop. He ordered a couple of tall OB beers, too. Justin nodded at that. God knew he could use a beer right now.

As their waitress wrote down the order, she kept looking from his older self to Justin and back again. "Twins," she said at last.

"Yeah," himself-at-forty said. Justin wondered if he was lying or telling the truth. *Damned if I know*, he thought as the waitress headed back to the kitchen. He wanted to giggle. This whole business was too bizarre for words.

Instead of giggling, he pointed at his older self. "Tell me one thing," he said in deep and portentous tones.

"What?" Himself-at-forty looked alarmed. Heaven only knew what he thought would come out of Justin's mouth.

Justin leered at him. "That the Rolling Stones aren't still touring by the time you're—I'm—forty."

"Well, no." Now his older self looked irked, as if he couldn't believe Justin would come out with anything as off-the-wall as that. *Don't have much fun at forty, do you?* Justin thought.

Here came the waitress with the beer. She hadn't asked either of the Justins for his driver's license. *A good thing, too.* Justin wondered what kind of license his older self had, or if himself-at-forty had one at all. But he had more important things to worry about. After the waitress went off to deal with a party of Koreans at another table, Justin said, "Okay, I believe you. I didn't think I would, but I do. You know too much—and you couldn't have pulled that quarter out of your ear from nowhere." He took a big sip of his OB.

"That's right," himself-at-forty said. Again, he sounded as if he knew everything there was to know. That rubbed Justin the wrong way. But, goddamn it, his older self did know more than Justin. *How much more?* Justin didn't know. *Too much more.* He was sure of that.

He drank his glass empty, and filled it from the big bottle the waitress had set in front of him. Pretty soon, that second glass was empty, too. Justin killed the bottle pouring it for a third time. He waved to the waitress for another beer. Why not? His older self was buying. Himself-at-forty hadn't even refilled his glass once yet. *Terrific*, Justin thought. *I turn into a wet blanket.*

Not only did the waitress bring his new beer, but also dinner: plates of strange vegetables (many of them potently flavored with garlic and chilies) for Justin and his older self to share and the marinated beef and pork. She started the gas fire under the grill and used a pair of tongs to put some meat on to cook for them. As the thinly sliced strips started sizzling, Justin pointed at them and said, "Oh my God! They killed Kenny!"

"Huh?" His older self clearly didn't remember *South Park*. *Wet blanket*, Justin thought again. Then a light came on his older self's eyes. "Oh." Himself-at-forty laughed—a little.

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Justin said, "If you'd have said that to me, I'd have laughed a lot harder." He decided to cut his older self some slack: "But the show's not big for you any more, is it? No, it wouldn't be. 2018. Jesus." He made a good start on the new OB.

His older self grabbed the tongs and took some meat. So did Justin. They both ate with chopsticks. Justin wasn't real smooth with them, but he looked down his nose at people who came to Asian restaurants and reached for the knife and fork. They could do that at home. Himself-at-forty handled the chopsticks almost as well as the Koreans a couple of tables over. *More practice*, Justin thought.

After they'd made a fair dent in dinner, Justin said, "Well, *will* you tell me what this is all about?"

His older self answered the question with another question: "What's the most important thing in your life right now?"

Justin grinned. "You mean, besides trying to figure out why I'd travel back in time to see me?" Himself-at-forty nodded, his face blank like a poker player's. Justin went on, "What else could it be but Megan?"

"Okay, we're on the same page," himself-at-forty said. "That's why I'm here, to set things right with Megan."

"Things with Megan don't need setting right." Justin could feel the beer he'd drunk. It made him sound even surer than he would have otherwise. "Things with Megan are great. I mean, I'm taking my time and all, but they're great. And they'll stay great, too. How many kids do we have now?" That was the beer talking, too. Without it, he'd never have spoken so freely.

"None." Himself-at-forty touched the corner of his jaw, where a muscle was twitching.

"None?" That didn't sound good. The way his older self said the word didn't sound good, either. Justin noticed something he should have seen sooner: "You're not wearing a wedding ring."

His older self nodded. He asked, "Does that mean we don't get married?"

"We get married, all right," his older self answered grimly. "And then we get divorced."

Ice ran through Justin. "That can't happen," he blurted.

He knew too goddamn much about divorce, more than he'd ever wanted to. He knew about the shouts and the screams and the slammed doors. He knew about the silences that were even deadlier. He knew about the lies his parents had told each other. He knew about the lies they'd told him about each other, and the lies they'd told him about themselves. He had a pretty fair notion of the lies they'd told themselves about themselves.

One of the biggest lies each of them had told him was, *Of course I'll still care for you just as much afterwards as I did before*. Megan wasn't the only one who envied him his apartment—a lot of people his age did. What the apartment meant to him was that his folks would sooner give him money to look out for himself than bother looking out for him. He envied Megan her parents who cared.

And now his older self was saying he and Megan would go through that? He sure was. His voice hard as stone, he squashed Justin's protest: "It can. It did. It will." That muscle at the corner of his jaw started jumping again.

"But—how?" Justin asked, sounding even in his own ears like a little boy asking how his puppy could have died. He tried to rally. "We aren't like Mom and Dad—we don't fight all the time, and we don't look for something on the side wherever we can find it." He took a long pull at his beer, trying to wash the taste of his parents out of his mouth. And he hadn't smiled back at that girl in the mall. He really hadn't.

With weary patience, his older self answered, "You can fight about sex, you can fight about money, you can fight about in-laws. We ended up doing all

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three, and so . . ." Himself-at-forty leaned his chopsticks on the edge of his plate and spread his hands. "We broke up—will break up—if we don't change things. That's why I figured out how to come back: to change things, I mean."

Justin poured the last of the second OB into his glass at gulped it down. After a bit, he said, "You must have wanted to do that a lot."

"You might say so." His older self drank some more beer, too. He still sounded scratchy as he went on, "Yeah, you just might say so. Since we fell apart, I've never come close to finding anybody who makes me feel the way Megan did. If it's not her, it's nobody. That's how it looks from here, anyhow. I want to make things right for the two of us."

"Things *were* going to be right." But Justin couldn't make himself sound as if he believed it. Divorce? He shuddered. From everything he'd seen, anything was better than that. In a small voice, he asked, "What will you do?"

"I'm going to take over your life for the next couple of months." His older self sounded absolutely sure, as if he'd thought it all through and this was the only possible answer. Was that how doctors sounded, recommending major surgery? Justin didn't get a chance to wonder for long; himself-at-forty plowed ahead, relentless as a landslide: "I'm going to be you. I'm going to take Megan out. I'm going to make sure things are solid—and then the superstring I've ridden to get me here will break down. You'll live happily ever after. I'll brief you to make sure you don't screw up what I've built. And when I get back to 2018, I *will have lived* happily ever after. How does that sound?"

"I don't know." Now Justin regretted pouring down two tall beers one right after the other. He needed to think clearly, and he couldn't quite. "You'll be taking Megan out?"

"That's right." Himself-at-forty nodded.

"You'll be . . . taking Megan back to the apartment?"

"Yeah," his older self said. "But she'll think it's you, remember, and pretty soon it'll be you, and it'll keep right on being you till you turn into me, if you know what I mean."

"I know what you mean. Still . . ." Justin grimaced. "I don't know. I don't like it." When you imagined your girlfriend being unfaithful to you, you pictured her making love with somebody else. Justin tried to imagine Megan being unfaithful to him by picturing her making love with somebody who looked just like him. It made his mental eyes cross.

His older self folded his arms across his chest and sat there in the booth. "You have a better idea?" he asked. He must have known damn well that Justin had no ideas at all.

"It's not fair," Justin protested. "You *know* all this shit, and I've gotta guess."

With a cold shrug, himself-at-forty said, "If you think I did this to come back and tell you lies, go ahead. That's fine. You'll see what happens. And we'll both be sorry."

"I don't know. I just don't know." Justin shook his head. He felt trapped, caught in a spider's web. "Everything sounds like it hangs together, but you could be bullshitting, too, just as easy."

"Yeah, right." Amazing how much scorn his older self could pack into two words.

Justin got to his feet, so fast it made him lightheaded for a couple of seconds—or maybe that was the beer, too. "I won't say yes and I won't say no, not now I won't. I've got your e-mail address. I'll use it." Out he went, planting his feet with exaggerated care at every stride.

Night had fallen while he and himself-at-forty were eating. He drove back to his apartment building as carefully as he'd walked. Picking up a 502 for driving under the influence was the last thing he wanted. One thought pounded in his head the whole way back. ***What do I do? What the hell do I do?***

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He'd just come out of the bathroom—the revenge of those two tall OBs—when the telephone rang. He wondered if it was his older self, calling to give him another dose of lecture. If it was, he intended to tell himself-at-forty where he could stick that lecture. "Hello?" he said suspiciously.

But it wasn't his older self. "Hiya," Megan said.

"Oh!" Justin shifted gears in a hurry. "Hi!"

"I just called up to say I think you're the bomb," she told him, and hung up before he could answer.

He stared at the telephone handset, then slowly set it back in its cradle. "God damn you," he whispered, cursing not Megan but his older self. "Oh, God damn you." He had a girl like this, and himself-at-forty was saying he'd lose her? *I can't do that*, he thought. *Whatever it takes, I can't do that.*

Even if it means bowing out of your own life for a while? Even if it means letting him stick his nose in? But his older self sticking his nose in didn't worry Justin. His older self sticking something else in . . .

I don't have to make up my mind right away. I'm not going to make up my mind right away. This is too important. And if my older self can't figure that out, tough shit, that's all.

Justin checked his e-mail even before he brushed his teeth the next morning. Himself-at-forty hadn't started nagging, anyhow. There was e-mail from Megan, though. Everything else could wait, but he opened that. It said, *The bomb. ;-)*

He grinned and shook his head. But the grin slipped a moment later. *I can't let her get away from me. Knowing she might . . .* He ground his teeth. He didn't just know she might. He knew she would. He'd never thought of being blind to the future as a blessing, but knowing some of it sure felt like a curse.

At work, his boss chewed him out for not paying attention to anything going on around him. He couldn't even blame the guy; he *wasn't* paying attention to anything going on around him. Too many important things spun through his mind.

He gulped lunch at the Burger King four doors down from the CompUSA, then went to the pay phones around the side of the building. He fed in a quarter—*not* the one from 2012; he was saving that—and a dime and called Megan. "Hello?" she said.

"Hi. I think you're the bomb, too." It wasn't *I love you*—it wasn't even close to *I love you*—but it was the best he could do.

Megan giggled, as if she'd been waiting by the telephone for him to call. "I bet you say that whenever you phone a girl who isn't wearing any clothes," she answered—and hung up on him again.

He spluttered, which did him no good. He reached into his pants pocket for more change to call her back and find out why she wasn't wearing any clothes—or if she really wasn't wearing any clothes. But that didn't matter. He had the image of her naked stuck in his head—which had to be just what she'd had in mind.

As he walked back, he realized he'd made up his mind. *I can't lose her. No matter what, I can't lose her.* If that meant letting his older self fix things up—whatever there was that needed fixing—then it did, and that was all there was to it.

Despite deciding, he took another day and a half to write the e-mail that admitted he'd decided. *All right, dammit*, he typed. *I still don't know about this, but I don't think I have any choice. If me and Megan are going to break up, that* can't *happen. You better make sure it doesn't.*

After he'd sent the e-mail, he looked at it again. It wasn't exactly gracious. He shrugged. He didn't feel exactly gracious, either.

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An answer came back almost at once. Himself-at-forty must have been hanging around the computer waiting for him to say something. *You won't be sorry*, the e-mail told him.

Whatever, Justin wrote. His hands balled into fists. He made them unclench. *How do you want to make the switch?*

Meet me in front of the B. Dalton's again, himself-at-forty replied. *Park by the Sears. I will, too. Bring whatever you want in your car. You can move it to the one I'm driving. I'll do the same here. See you in two hours?*

Justin sighed. *Whatever*, he said again. Packing didn't take anything like two hours. He thought about bringing the iMac along, but ended up leaving it behind and taking his PowerBook instead. It was old, but it would do for games and for the Net. He scribbled a note and set it by the iMac's keyboard: *In case you don't remember, here's Megan's phone number and e-mail. Don't screw it up, that's all I've got to tell you.*

Once he'd stuffed everything he thought he needed into a pair of suitcases, he put them in the trunk of his Toyota and headed for the mall. He'd gone only a couple of blocks when he snapped his fingers and swung down to the Home Depot on Roscoe first.

Even with the stop, he still took his place in front of the bookstore before his older self got there. This time, seeing himself-at-forty made him grim, not boggled. "Let's get this over with," he said.

"Come on. It's not a root canal," his older self said. Justin shrugged. He'd never had one. Himself-at-forty went on, "Let's go do it. We'll need to swap keys, you know."

"Yeah," Justin said. "I had spares made. How about you?"

"Me, too." His older self grinned a lopsided grin. "We think alike. Amazing, huh?"

"Amazing. Right." Justin abruptly turned away and started walking toward Sears and the lot beyond it. "This better work."

"It will." Himself-at-forty sounded disgustingly confident.

The two Toyotas sat only a couple of rows apart. They were almost as much alike as Justin and his older self. Justin moved his things into the other car, while himself-at-forty put stuff in his. They traded keys. "You know where I live," Justin said. "What's my new address?"

"Oh." His older self gave it to him. He knew where it was—not as good a neighborhood as the one the Acapulco was in. Himself-at-forty went on, "The car's insured, and you'll find plenty of money in the underwear drawer." His older self patted him on the shoulder, the only time they'd touched other than shaking hands. "It'll be fine. Honest. You're on vacation for a couple of months, that's all."

"On vacation from my *life*," Justin exclaimed. He glared at his older self. "Don't fuck up, that's all."

"It's my life, too, remember." Himself-at-forty got into the car Justin had driven to the mall. Justin went to his older self's Toyota. Still half wondering if this were some elaborate scam, he tried the key. The car started right up. Justin drove off to see where the hell he'd have to wait this out.

Sure enough, the Yachtsman and the apartment buildings on the block with it were older and tireder-looking than the Acapulco and its surroundings. It wasn't a neighborhood where guys sold crack from parked cars, but it might be heading that way in a few years. The one bright spot Justin saw was the Denny's on the corner. If he got sick of frozen dinners and his own bad cooking, he could always eat there.

He found his parking space under the apartment building. When he went out to the lobby, a mailbox had KLOSTER Dymo-taped onto it. He checked. His

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older self hadn't got any mail. Justin went inside and found his apartment. The door key and dead-bolt key both worked. "Well, what have we got?" he wondered.

When he discovered what he had, his first impulse was to walk right out again. The TV just plugged into the wall: no cable, not even a VCR hooked up. The stereo had to have come out of an antique store. It played cassettes and vinyl, but not CDs. He could play CDs on the PowerBook, but even so . . .

He opened the underwear drawer, more than half expecting BVDs and nothing else. But under the briefs lay . . . "Christ!" he exclaimed. How much was there? He picked up wad after wad of cash, threw them all down on the bed, and started counting. By the time he was through, he'd had almost as much fun as he'd ever had in his life.

Close to seventy grand, he thought dazedly. *Jesus*. All at once, he stopped doubting his older self's story. Nobody—but nobody—would spend, or let him spend, that kind of money on a scam. The bills weren't even crisp and new, as they might have been if they were counterfeits. They'd all been circulating a good long while, and couldn't be anything but genuine.

"Okay," he said, fighting the impulse to count them again. "I'm on vacation. Let the good times roll." He *did* recount a couple of thousand dollars' worth, just for the hell of it.

He'd never been in a spot where he could spend all the money he wanted, do whatever he felt like doing. If he wanted to go out and get a VCR, he could—and he intended to. He could charge right down to Circuit City or Best Buy or Fry's and . . .

"Uh-oh," he muttered. If he went to any of those places, there was some chance he'd run into Megan. His older self didn't want him running into Megan for a while, and his older self had left him all this money to play around with so he wouldn't. He shrugged. He could go over to Burbank or out to Simi Valley or wherever and get a VCR. Then he could charge right down to Blockbuster and rent enough tapes to keep him from getting too . . .

Uh-oh. He didn't say it this time, but he thought it. Megan was liable to show up at either of the local Blockbusters; she liked watching movies on video as much as everybody else did.

"Okay," Justin said, as if somebody were arguing with him. "I'll find some video place out in the boonies, too."

That made him happier. He had time to kill—nothing but time to kill—and movies were a great way to kill it. But he couldn't watch movies and play computer games all the damn time. *I can go down to* . . . But that thought stopped before it was even half formed. He couldn't go to the mall, not to Northridge, not to Topanga Plaza, not even to the half-dead Promenade farther down Topanga or to tacky Fallbrook. Megan visited all of them.

"Shit," he said in a low voice. And he really couldn't go to any of his favorite restaurants, because where would himself-at-forty be taking Megan? To one of them or another, sure as hell. What would she think if she were with his older self and then saw him come in by himself in different clothes? Nothing good, that was for damn sure.

Great, Justin thought. *I can do whatever I want, as long as I don't do it in any of the places I usually go to. Or I can just sit here in this miserable apartment and jack off*. He suspected he'd end up doing a lot of that. Thinking about Megan immediately made him want to do more than think about Megan: he was, after all, twenty-one.

Down, boy, he told himself. Himself didn't want to listen. While he was holed up here by his lonesome, himself-at-forty would be taking Megan out, taking Megan home, taking Megan to bed. No, he didn't like that worth a rat's ass. He tried again to imagine Megan being unfaithful to him with somebody with

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his own face. He came a lot closer to succeeding this time.

He paced out to the kitchen. Even looking at the bed turned him on and pissed him off, regardless of whether it had cash strewn all over it. When he opened the refrigerator, he found a couple of six-packs of microbrews along with fresh vegetables and other things he was unlikely to eat. He tried to unscrew the cap from one of the beers, only to discover it didn't unscrew. That meant he had to rummage in the drawer till he came up with an opener. Once he got the cap off, he threw it at the wastebasket—and missed. He had to bend down and drop it in—and even then he almost missed again.

Sighing, Justin sipped the hard-won Anchor Porter . . . and made a horrible face. "People pay a buck a bottle for *this?*" he said. "Jesus! Gimme Coors Light any day."

When he opened the freezer, he found steaks and chops and chicken in there. He supposed he could do up the steaks in a pan on the stove, but chicken was out of his culinary league. Fortunately, there were also several frozen dinners. He didn't know what he would have done if his older self had turned into a total foodie.

Like hell I don't know, he thought, and grinned. *I'd just eat out all the time. With that Denny's right at the end of the block, I might anyway.*

After watching network TV that night, he realized he would have to get a VCR ASAP if he wanted to stay anywhere close to sane. He ate bacon and eggs and hash browns at the Denny's the next morning, then drove over to an electronics place he knew on Ventura Boulevard in Encino—only twenty minutes' drive from the Yachtsman, but not a place where he was at all likely to run into Megan. He bought the VCR, put the box in his trunk, and headed to a Blockbuster a few doors away to get some tapes.

His address came up on their computer system. "You do know we have locations closer to your home, sir?" the clerk said.

"Yeah." Justin nodded. "This is near where I work."

He'd never been a great liar. He was, at the moment, wearing a Dilbert T-shirt and a pair of baggy shorts. The clerk raised an eyebrow. But Justin's credit checked out okay, so that was all she did.

Having lugged the VCR into his apartment, he discovered, not for the first time, that being a computer-science major didn't make the damn thing easy to set up. He fumed and mumbled and cussed and finally got the gadget acting the way it was supposed to. With *Deep Impact* on the TV and a Coke in his hand, life looked better.

He put his feet on the coffee table and belched enormously. Nothing to do but kick back and watch movies for a couple of months? *Okay, I can handle it*, he thought. Then he snapped his fingers. "Potato chips!" he said out loud. "Doritos. Whatever."

That day went fine. The next day went all right. By the middle of the afternoon on the third day, he was sick of movies and computer games and hoped he'd never see another nacho-cheese Dorito as long as he lived. He went into the bedroom and picked up the phone. He'd dialed four digits of Megan's number before he remembered he wasn't supposed to call her.

"God damn it," he muttered. "This is so lame. What am I going to do, stay cooped up here till I get all dusty?"

His older self wanted him to do exactly that. His older self had left him plenty of money so he would do exactly that. But what good was the money if he had trouble finding places to blow it? After staring at the walls—and the TV screen, and his laptop's monitor—for two days straight, his affection for his older self, which had never been high, sank like the Dow on an especially scary day. He'd

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never understood people saying money couldn't buy happiness. Now maybe he did.

He wanted to talk with his girlfriend. Hell, he wanted to lay his girlfriend. Himself-at-forty was telling him he couldn't do either. Himself-at-forty, the son of a bitch, was probably doing both. Justin was no better at handling frustration than anyone else his age. The hornier he got, the worse he got, too.

If he couldn't talk to Megan, he damn well could talk to his older self. He dialed the number at his apartment, which felt funny. He never called there. Why would he? If he wasn't home, who would answer? A burglar?

But somebody was home to answer now. And, after three rings, somebody did. "Hello?" Himself-at-forty sounded as if he were talking from deep underwater.

"Hi," Justin said cheerfully; he had all he could do not to say *hiya*, the way Megan did. "How are things?"

"Things are fine," his older self answered after a longish pause. He still sounded like hell; if he hadn't been ridden hard and put away wet, Justin had never heard anybody who had. Another pause. Then himself-at-forty tried again: "Or they were till you called. I was asleep."

"*Now?*" Justin exclaimed in disbelief. He looked at his watch: half past two. He didn't think he'd been asleep at half past two since he was three years old and quit taking naps. "I called now 'cause I figured you wouldn't be."

"Never mind." His older self yawned, but seemed a little less fuzzy when he went on, "Yeah, things are okay. We went to the Probe last night, and—"

"*Did* you?" Justin broke in. He didn't like the way that sounded: him stuck here in this miserable place, himself-at-forty having a good time at his favorite club. No, he didn't like that at all. "What else did you do?"

"That after-hours place," his older self answered. "Some guy came through with fliers, so I knew how to get there."

Yeah, you'd have forgotten, wouldn't you, you sorry bastard? Aloud, Justin said, "Lucky you. And what *else* did you do?" He could imagine Megan in his older self's arms, all right. Now he could. He'd had plenty of time to try. Practice made perfect, dammit. He could hate what he imagined, too.

"About what you'd expect," himself-at-forty said. Christ, he sounded arrogant. "I'm you, remember. What would you have done?" Justin sighed. He knew what he would have done, by God. But no. He'd stayed here by his lonesome—by his very lonesome—so his older self could do it instead. He sucked in a long, angry breath preparatory to telling himself-at-forty where to head in. Before he could, his older self went on, "And when I took her home, I told her I loved her."

"Jesus!" Justin yelped, forgetting whatever else he might have said. "What did you go and do that for?"

"It's true, isn't it?" his older self asked.

"That doesn't mean you've got to *say* it, for Christ's sake," Justin answered. He shook his head in disbelief, though his older self wasn't there to see it. His parents must have said they loved each other once upon a time, too, and how had that turned out? "What am I suppose to do when you go away?"

"Marry her, doofus," himself-at-forty said, as if it were just that simple. "Live happily ever after, so I get to live happily ever after, too. Why the hell do you think I came back here?"

"For your good time, man, not mine," Justin snarled. "I'm sure not having a good time, I'll tell you." He belched again. No surprise—how many Cokes had he poured down since he got to this place? Too many. With the carbonation, he tasted stale nacho cheese.

His older self took a deep breath, too, and said, "Look, chill for a while, okay? I'm doing fine."

That only made Justin angrier. "Sure you are. You're doing fucking great. What about me?"

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"You're fine. Chill. You're on vacation," himself-at-forty answered. If he didn't know everything, he didn't know he didn't know everything. "Go ahead. Relax. Spend my money. That's what it's there for."

When his older self mentioned the money, Justin forgot how chuffed he was, at least for a little while. "Where'd you get so much?" he asked. "What did you do, rob a bank?"

"It's worth a lot more now then it will be then," his older self told him. "Inflation. Have some fun. Just be discreet, okay?"

Which brought Justin back to square one. His older self kept trying to blow him off, and he didn't want to put up with it. "You mean, get out of your hair."

"In a word, yes." Himself-at-forty sounded as if he was having trouble putting up with Justin, too.

"While you're in Megan's hair." No, Justin had no trouble at all seeing pictures in his mind, pictures nastier than any he could have pulled off the Net. He sighed, trying to make them go away. "I don't know, dude."

"It's for you," himself-at- forty said. "It's for her and you."

That, goddammit, was the trump card. If Justin-now was fated to break up with Megan, he didn't see that he had any choice other than letting his older self set things right. He hated the idea. Every minute he spent in this miserable apartment made him hate it more. But he couldn't find any way around it. Get married and get divorced? That was worse. "Yeah," he said, and hung up.

Every minute he spent in that miserable apartment . . . from then on, he spent as little time as he could there. That worked better than staring at the TV and the PowerBook's monitor and, most of all, the four walls. When he was out and doing things, he didn't think about himself-at-forty and Megan . . . so much.

Getting out would have worked better still if he'd been able to go to the places he really liked, the local malls and the movie theaters and coffeehouses and restaurants where he'd gone with Megan. But he didn't dare. He couldn't imagine what he'd do if he saw her and his older self together. And what would himself-at-forty do? And Megan? Those were all terrific questions, and he didn't want to find out the answers to any of them.

So he went to places where he could be sure he wouldn't run into Megan or anybody else he knew. He killed an afternoon at the Glendale Galleria. He killed a whole day at the enormous Del Amo mall down in Torrance, which was supposed to be the biggest shopping center this side of the Mall of America. By the time he'd trekked from one end of it to the other, he believed all the hype. He hadn't come close to hitting all the stores that looked interesting.

He grabbed some pizza down there, and stayed for a movie after the shops closed. That turned out to be a mistake. Sitting in a theater by himself was the loneliest thing he'd ever done, much worse than watching a movie on the VCR without any company. All the other people there seemed to have somebody else to have a good time with, and he didn't.

And he was sure Megan would have loved this flick. She'd have gone all slobbery over the male star, and he could have had a good time teasing her about it. And she would have told him he only went to movies for the special effects—and they were pretty damn special. And then they would have gone back to his place and screwed themselves silly.

He went back to the place that wasn't his: a long haul up the San Diego Freeway, which had plenty of traffic even after eleven at night. When he got there, he masturbated twice in quick succession. It wasn't the same—it wasn't close to the same—but it let him fall asleep.

The next morning, he drove out Topanga Canyon Boulevard to the ocean

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and spent the day at Zuma Beach. That would have been better with Megan along, too, but it wasn't so bad by itself, either: nothing to do but lie there and watch girls and keep himself well greased with sunscreen. It let him get through another day without being too unhappy.

But, in spite of all the sunscreen, he came home with a burn. He was so fair, he could sunburn in the moonlight. Hot and uncomfortable, he couldn't fall asleep. Finally, he quit trying. He put on some shorts and a T-shirt and went out front to watch TV. That experiment didn't last long: nothing there but crap of the purest ray serene. After about twenty minutes, he turned it off in disgust.

"Now what?" he muttered. He still wasn't sleepy. He walked back into the bedroom and got his car keys. He was an L.A. kid, all right: when in doubt, climb behind the wheel.

Driving around with a Pulp cassette in the stereo and the volume cranked made Justin feel better for a while. But he wasn't just driving around. His hands and feet figured that out a little before his head did. The conscious part of his mind was surprised to discover they'd sent him down his own street toward his own apartment building.

If he parked between the Acapulco and the building next to it, he could look between them and see his bedroom window, a foreshortened rectangle of light. The curtain was drawn, so light was all he could see, light and, briefly, a moving shadow. Was that his older self? Megan? Were they both there? If they were, what were they doing? *Like I don't know*, Justin thought.

"I've got spare keys," he told himself in conversational tones. "I could walk in there and . . ."

Instead, he started up the car and drove away, fast. What would he do if he did walk in on himself-at-forty and Megan? He didn't want to find out.

The sunburn bothered him enough the next day that staying in the apartment and being a lump suited him fine. The day after, though, he felt better, which meant he also started feeling stir crazy. He went out and drove some more: west on the 118 into Ventura County. Simi Valley and Moorpark were bedroom communities for the Valley, the way the Valley had been a bedroom community for downtown L.A. when his parents were his age.

I could be going to Paris or Prague or Tokyo, he thought as he put the pedal to the metal to get on the freeway, *and I'm going to Simi Valley?* But, in fact, he couldn't go to Paris or Prague or Tokyo, not without a passport, which he didn't have. And he didn't really want to. He just wanted to go on living the way he had been living. He'd spent his whole life in the Valley, and was in some ways as much a small-town kid as somebody from Kokomo or Oshkosh.

Justin didn't think of himself like that, of course. As far as he was concerned, he stood at the top of the cool food chain. And so, when he'd pulled off the freeway and driven the couple of blocks to what his Thomas Brothers guide showed as the biggest shopping center in Simi Valley, he made gagging noises. "It's not even a mall!" he exclaimed. And it wasn't, not by his standards: no single, enormous, air-conditioned building in which to roam free. If he wanted to go from store to store, he had to expose his tender hide to the sun for two, sometimes three, minutes at a time.

He almost turned around and drove back to his apartment. In the end, with a martyred sigh, he parked the car and headed toward a little mom-and-pop software store. It turned out to be all PC stuff. He had Virtual PC, so he could run Windows programs on his Macs, but he left in a hurry anyway. They'd go okay on the iMac, which was a pretty fast machine, but they'd be glacial on the old PowerBook he had with him.

The Wherehouse a couple of doors down was just as depressing. Grunge, metal, rap, bands his parents had lis-

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tened to—yeah, they had plenty of that stuff. British pop? He found one, count it, one Oasis CD, filed under THE REST OF "O." Past that? Nada.

"Boy, this is fun," he said as he stomped out in moderately high dudgeon. He spotted a Borders halfway across the shopping center and headed toward it. Even as he did, he wondered why he bothered. The way his luck was running, it would stock a fine assortment of computer magazines from 1988.

Behind him, somebody called, "Justin!" He kept walking. Half the guys in his generation—all the ones who weren't Jasons—were Justins. But the call came again, louder, more insistent: "Hey, Justin!"

Maybe it is me, he thought, and turned around. A startled smile spread over his face. "Lindsey!" he said. Sure as hell, Lindsey Fletcher came running up to him, rubber-soled sandals scuffing on the sidewalk. He opened his arms. They gave each other a big hug.

"I can't believe it," Lindsey said. "What are you doing up here? You never come up here. I've never seen you up here, anyway." She spoke as if one proved the other.

She'd always liked to talk, Justin remembered. He remembered the mole on the side of her neck, too. It was still there, a couple of inches above the top of her T-shirt. "How are you?" he said. "How've you been?"

"I'm fine." She looked him up and down. "God, you haven't changed a bit."

"Yeah, well," Justin said, a little uncomfortably. He knew how little he would change, too, which she didn't.

"What *are* you doing up here?" Lindsey asked again.

"Whatever," Justin answered. "A little shopping. Hanging out. You know."

"Here? It's a lot better in the Valley." She looked astonished and sounded wistful.

"Yeah, well," he said again: he'd already discovered that. "Something new."

"Slumming," Lindsey told him. "But as long as you're here, that donut place over there isn't too bad." She pointed. "I mean, if you want to get something and, you know, talk for a little while."

"Sure," Justin said. Like a lot of the little donut shops in Southern California, this one was run by Cambodians: a middle-aged couple who spoke with accents and a teenage boy who talked just like Justin and Lindsey. Lindsey tried to buy; Justin wouldn't let her, not with his older self's money burning a hole in his wallet. They got jelly donuts and big fizzy Cokes, sat down at one of the half-dozen or so little tables in the shop, and proceeded to get powdered sugar all over their faces.

"What have you been up to?" Lindsey asked, dabbing at herself with a paper napkin.

"Finished my junior year at CSUN," Justin answered, pronouncing it *C-sun* the way anybody who went there would.

"What's your major?"

"Computer science. It's pretty interesting, and it'll pay off, too—I've got a summer job at the Northridge CompUSA." *Which my older self is welcome to.* Half a beat slower than he should have, Justin asked, "How about you?"

"I've been going to Moorpark Community College kind of on and off," Lindsey said. "I've got a part-time job, too—pet grooming."

"Ah, cool," Justin said. "You always did love animals. I remember."

She nodded. "Maybe I'll end up doing that full-time. If I can save some money, maybe I'll try and get into breeding one of these days." She sipped at her Coke, then asked, "Do I want to know about your parents?"

"No!" Justin exclaimed. "God no! Let's see . . . I think you'd already moved here when my mom came out of the closet."

"Oh, Lord." Lindsey's eyes got big. "That must have been fun."

"Yeah, right," Justin said. "Somebody

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shoot me quick if I ever set out to discover myself." He turned his mother's favorite phrase into a curse.

Lindsey didn't ask about his father. The bad news there had been obvious while she still lived in the Valley. After some hesitation, she did ask, "What about you? Are you . . . seeing anybody?"

Justin had just taken a big bite of jelly donut, so he didn't have to answer right away. When he did, he did his best to make it sound casual: "Uh-huh."

"Oh." Lindsey looked disappointed, which was flattering. And Justin couldn't have sounded too casual, because she asked, "Are you serious?"

"Well, it kinda looks that way," he admitted. And then, not so much out of politeness as because he didn't want to think about how he *wasn't* seeing Megan right this minute and his older self *was*, he said, "What about you?"

Lindsey shook her head. A strand of her short blond hair—she'd worn it longer in high school—fell down onto her nose. She brushed it away with her hand. "Not right now. Not so it matters, anyhow, I mean. I've gone with a few guys since I got up here, but nobody I'd want to settle down with. You're lucky."

She sounded wistful again. She also sounded as if she really meant it. She'd never begrudged happiness to anybody else. Justin would have had trouble saying the same thing—he was mad as hell thinking about himself-at-forty having a good time with Megan. And how lucky was he if his older self had to come back from 2018 to try to straighten things out? But Lindsey didn't—couldn't—know about that, of course.

He finished the donut in a couple of big bites. "I better get going. I have to be at work before too long." He could almost feel his nose getting longer, but the lie gave him an excuse to get away.

"Okay." Lindsey stood up, too. "It was great to see you. I'm glad you're doing so well." She sounded as if she really meant that, too. Nope, not a mean bone in her body. She gave him another hug, this one a little more constrained than the one when they first ran into each other. "Listen, if you ever want to just talk or anything, I'm in the book." She made a face. "I sorta wish I wasn't, but I am. I get more damn telemarketers than you can shake a stick at."

"Always at dinnertime, too," Justin said, and she nodded. "They ought to do something about 'em." He didn't know who *they* were or what they could do, but that didn't stop him from complaining. He headed for the door. "So long."

"So long, Justin." Lindsey followed, but more slowly, making it plain she wasn't going to come with him once they got outside. He headed for his car. Lindsey walked in the direction of the Wherehouse he'd already found wanting. He looked back toward her once. She was looking toward him. They both smiled and waved. Justin pulled out his keys, unlocked the Toyota, and slid inside. Lindsey went into the Wherehouse. Justin drove back to the Valley. For some reason he couldn't quite fathom, he didn't feel so bad once he got there.

He kept feeling halfway decent, or even a little better than halfway decent, for a while afterwards. The driving need to call up either his older self or Megan and find out how things were going went away. What that amounted to, of course, was finding out whether anybody in the whole wide world cared if he was alive—and a good-sized fear the answer was no. Lindsey Fletcher cared. Justin didn't think of it in those terms—on a conscious level, he hardly thought of it at all—but that was what it added up to.

And so, over about the next ten days, he found things to do and places to go that let him kill time without seeming to be doing nothing but killing time. He drove over to the Sherman Oaks Galleria, which had gone from the coolest place in the world to semi-ghost town in one fell swoop after the '94 quake. He

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beat the parking hassles at the new Getty Museum looming over the San Diego Freeway by taking a cab there—*spending my older self's money*, he thought, feeling half virtuous and half *so there!* He found a pretty good Japanese restaurant, Omino's, on Devonshire near Canoga. It'd be a good place to take Megan once himself-at-forty got the hell back to 2018 where he belonged.

"Superstrings," Justin muttered in the apartment that wasn't his. He'd fought his way through his physics classes; he couldn't say much more than that. He wished he knew more. His older self did, dammit. That was definitely something to think about when he planned his schedule for his senior year.

Before so very long, though, he started muttering other, more incendiary, things. His decent mood didn't last, not least because he didn't fully understand what had caused it in the first place. The apartment in the Yachtsman started feeling like a prison cell again. Going out stopped being fun. Minutes crawled past on hands and knees.

Justin thought about calling his older self to complain: he thought about it for a good second and a half, as a matter of fact. Then he laughed a bitter laugh that lasted a lot longer. He knew just what his older self would say. *Live with it.* He could tell himself that and save the price of a phone call. It wasn't quite *fuck off and die*, but close enough for government work.

Besides, he didn't really want to talk to himself-at-forty. He wanted to talk to Megan. His older self had given him all sorts of reasons why that wasn't a good idea. Justin had only one reason why it was: he was going out of his tree because he couldn't. Eventually, that swamped everything his older self had said.

He felt as if he'd just pulled off a jailbreak when he dialed her number. Her father answered the phone. "Hi, Mr. Tricoupis," he said happily. "Can I talk to Megan, please?"

Instead of saying *Sure* or *Hang on a second* or anything like that, Megan's father answered, "Well, I don't know, Justin. I'll see if she wants to talk to you."

I'll see if she wants to talk to you? Justin thought. *What the hell's going on here?* But he couldn't even ask, because a clunking noise meant Mr. Tricoupis had put the phone down. He could only wait.

After what seemed like forever but couldn't have been more than half a minute, Megan said, "Hello?" He needed no more than the one word to hear that she didn't sound happy.

But he felt something close to delirious joy at hearing her voice. "Hi!" he burbled. "How you doing?"

Another pause. Then, very carefully, Megan said, "Justin, didn't I tell you last night not to call here for a while? Didn't I say that?"

He knew what that meant. It meant his older self wasn't as goddamn smart as he thought he was. By the look of things, it also meant he'd have to bail himself-at-forty out instead of the other way round. He wondered if he could. He and Megan hadn't had any great big fights, which meant he had no sure feel for how to fix one.

Silly seemed a good idea. "Duh," he said, the standard idiot-noise of the late '90s, and then, "My big mouth." That wasn't just an apology; it was also the title of an Oasis song Megan liked.

"Your big mouth is right," she said, but a little of the hard edge left her voice—either that or wishful thinking was running away with Justin. She wasn't going to let him down easy, though; she went on, "Do you have any idea how far over the line you were? Any idea at all?"

"Definitely maybe," he answered: an Oasis album title that had the added virtue of keeping him off the hook.

He wasn't sure Megan had noticed the first title he used, but she definitely noticed the second; he heard her snort.

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"You're funny now," she said, as if fighting to stay mad. "You weren't funny last night after the movie, believe me you weren't."

Which movie? Justin wondered. He could hardly ask; he was supposed to know. He couldn't even waste any more time cursing his older self, not when he was trying to jolly Megan back into a good mood. "Charmless man, that's me," he said. It wasn't just him—it was also a track on a recent Blur CD.

"Justin . . ." But Megan was fighting back laughter now. "What am I supposed to do about you?"

"Roll with it, my legendary girlfriend," Justin said: one Oasis song, one from Pulp. "I'm just a killer for your love. Advert." Two from Blur. He didn't know how long he could keep it up, but he was having fun while it lasted.

With that, Megan gave up the fight and giggled. "Okay," she said. "Okay. I didn't think you could do anything to make me forget last night, but you did. How did you manage?"

"Only tongue will tell," he answered gravely. "Worked a miracle." That set Megan off again. She recognized Trash Can Sinatras titles, sure enough, and there probably weren't three other people in the San Fernando Valley who would have.

"I'll see you soon, Justin," she said, and hung up.

But she wouldn't be seeing him, dammit. She'd be seeing his older self. Justin started to call his old apartment to tell himself-at-forty what he thought of him, but held off. He didn't see what good it would do. He wasn't quite ready to throw his older self out of his place on his ear, and nothing short of that would make a nickel's worth of difference. *I'll wait*, he thought. *For a little while.*

He didn't have to wait long. Twenty minutes later, the phone rang. He hurried into the bedroom from the kitchen, hoping it was Megan. He'd just picked up the phone when he remembered she didn't have the number here. By then, he was already saying, "Hello?"

"Oh, good. You're home." His older self sounded half-disappointed Justin hadn't walked in front of a truck.

"Oh, it's you," Justin answered, still wishing it were Megan. Throwing himself-at-forty out on his ear suddenly looked more attractive. He went on, "No, *you're* home. I'm stuck here." He looked around the little bedroom, feeling like a trapped animal again.

His older self had gone into dictator mode: "Didn't I tell you to lay low till I was done here? God damn it, you'd better listen to me. I just had to pretend I knew what Megan was talking about when she said I'd been on the phone with her."

"She's my girl, too," Justin said. "She was my girl first, you know. I've got a *right* to talk with her." As talking Lindsey Fletcher out in the wilds of Simi Valley had, it reminded him he was alive.

But himself-at-forty didn't want to hear any of that. Maybe he wasn't a dictator; maybe he was just a grownup talking down to a kid. Whatever he was, he sure sounded like somebody convinced he knew it all: "Not if you want her to keep being your girl, you don't. You're the one who's going to screw it up, remember?"

"That's what you keep telling me." Justin was getting sick of hearing it, too. "But you know what? I'm not so sure I believe you any more. When I called her, Megan sounded like she was really torqued at me—at you, I mean. So it doesn't sound like you've got all the answers."

"*Nobody* has *all* the answers." His older self sounded as if he believed that. Justin didn't; like *The X-Files*, he was convinced the truth was out there, provided he could find it. And then, throwing gasoline on the fire, his older self added, "If you think you've got more of them than I do, you're full of shit."

That did it. Justin wanted to turn his

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head real fast to see if he had smoke coming out of his ears. "You want to be careful how you talk to me," he ground out, biting off each word. "Half the time, I still think your whole setup is bogus. If I decide to, I can wreck it. You know damn well I can."

If that didn't scare the crap out of himself-at-forty, Justin didn't know what would. But if it did, his older self didn't show it, damn him. Instead, he kicked back with both feet, like a mule: "Yeah, go ahead. Screw up your life for good. Keep going like this and you will."

And that scared the crap out of Justin. Himself-at-forty had to know it would. It was the only weapon he had, but it was a nuke. Justin tried not to let on that he knew it, saying, "You sound pretty screwed up now. What have I got to lose?"

Maybe, for once, he got through to himself-at-forty, because his older self, also for once, stopped trying to browbeat him and started trying to explain: "I had something good, and I let it slip through my fingers. You wreck what I'm doing now, you'll go through life without knowing what a good thing was." And then he trotted out the ICBMs again. "You want that? Just keep sticking your nose in where it doesn't belong. You want to end up with Megan or not?"

There it was. Justin did want that. He wanted it more than anything else in the world, and he couldn't let on that he didn't. If himself-at-forty was bluffing, he'd just got away with it. "All right," Justin said, though it was anything but all right, and he didn't think he sounded as if it were. "I'll back off—for now."

He got the last word by hanging up. Then he masturbated again. It made him feel good, but it didn't come close to making him feel better.

He rented *Titanic* and watched it several times over the next few days, which certainly went a long way toward keeping him out of circulation. He wasn't watching it for the romance. Christ, no. Jack died. He wanted his life with Megan to go on and on, even if he couldn't stand Celine Dion.

What he watched obsessively was the way the enormous liner took on water and sank after it hit the iceberg. Here in this apartment that wasn't his, as far out of the loop as he could be, he felt he was taking on water, too.

Running into Lindsey Fletcher, sitting down with her, and eating messy jelly donuts and talking had let him believe for quite a while that he wasn't alone in the world. He cared about Megan a lot more, but talking with her on the phone didn't satisfy his people jones nearly as long. For one thing, talking on the phone was like looking at a picture of a great dinner—pretty, yeah, but not the real thing.

And, for another, he'd had the row with himself-at-forty just afterwards. He might have stayed happier longer if he hadn't. The main reason—the only reason—he'd gone along with his older self and this whole craziness was that he couldn't stand the idea of losing Megan, of having to go through a divorce. If his older self could smooth things out now, make sure that never happened, great.

But if his older self was fighting with Megan, was making her angry at him . . . Where the hell did that leave Justin? He'd already saved the day once, which made him want to gallop back into the scene like a knight in shining armor coming to rescue the fair maiden. Would he rescue her, though? Or would he gallop in and screw things up, the way his older self said?

He didn't hop into his car—which was actually his older self's car—and drive over and throw himself-at-forty out of his rightful apartment. But he couldn't stand staying here and doing nothing, either, not for very long he couldn't.

After a bit more sitting on his hands, he hit on a compromise—or, to look at it another way, he found an excuse for doing what he wanted to do anyhow. *I'll call Megan*, Justin thought. *I did some*

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good the last time. Maybe I can do some more now. And then I'll brief my older self on what we talked about, so he doesn't get caught short.

Man is the rationalizing animal.

Justin felt good, felt alive, felt part of things again, as he dialed the phone. It rang a couple of times, then somebody picked it up. "Hello?" Hearing Megan's voice made him smile big and wide. It also made him horny as hell.

"Hiya!" He gave her back her own favorite greeting.

Silence, about fifteen seconds' worth, on the other end of the line. Then Megan said, "Justin, this is way over, I mean *way* over, the top. Didn't I tell you not two hours ago that I didn't want to see you anymore, I didn't want to talk to you anymore, I didn't want to have anything to do with you anymore? Didn't I?"

"But—" Justin heard the words, but he had a hard time making them mean anything.

Megan didn't give him much of a chance, either. She went on, "Didn't I tell you that if I ever changed my mind, *I'd* call *you?* Didn't I? I don't want to be on the phone with you any more, Justin, I mean I really don't." She sounded furious, bigtime furious.

"Wait a minute," Justin said frantically. "What—?"

He was trying to say, *What are you talking about?* but he never got the chance. Megan filled in the blank for him: "What about the sex? I already told you, I don't care how good it was. I don't care that it got better the last couple weeks, either. I don't want you treating me like I'm twelve years old, and I *do* care about that. Now get out of my life, goddammit. Goodbye!" The phone crashed down.

Slowly, like a man in shock—which he was—Justin hung up, too. *I don't care that it got better the last couple weeks, either?* One day, when he had time to think about it, that would be a separate torment of its own. Right now, it was just part of the general disaster.

"What do I do?" he asked, as if the bedroom could tell him. What he wanted to do was call Megan back and explain, really explain, but that wasn't gonna fly. If he got in even two words before she hung up on him, it'd be a miracle.

"E-mail!" he exclaimed, and ran for his PowerBook. He wrote the message. He sent it. Less than a minute later, it came back, with PERMANENT FATAL ERROR at the top and an explanatory paragraph underneath saying that she was refusing all mail from his address. "Jesus!" he cried in real anguish. "I've been bozo-filtered!" That added insult to injury, and none of this, not one single thing, was his fault.

He knew whose fault it was, though. Anguish didn't last. Rage replaced it.

The phone rang four times before his older self answered. "Hello?" He sounded groggy.

Justin didn't much care how he sounded. "You son of a bitch," he snarled. "You goddamn stupid, stinking, know-it-all son of a bitch."

"I'm sorry," himself-at-forty said. Of all the useless words in the world right now, those were the big two. "I tried to—"

"I just tried calling Megan," Justin said, interrupting his older self the way Megan had interrupted him. "She said she didn't want to talk to me. She said she never wanted to talk to me again. She said she'd told me she never wanted to talk to me again, so what was I doing on the phone right after she told me that? Then she hung up on me." He didn't say anything about the refused e-mail. Somehow, that hurt even worse, too much to talk about.

"I'm sorry," his older self said again. "I—"

"Sorry?" Justin yelled. If he hadn't had a buzz cut, he might have pulled his hair. "You think you're sorry now? You don't know what sorry is, but you will. I'm gonna beat the living shit out of you,

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dude. You think you can get away with that, you're full of—" He hung up on himself-at-forty even harder than Megan had hung up on him.

He hadn't been in a fight since middle school, and he'd lost that one. It didn't matter. He stormed out of the apartment, slamming the door behind him. He ran down to his car—no, to his older self's car—and headed to his old apartment, his proper apartment, as fast as he could go.

That meant somewhere between ten and fifteen minutes. He was still incandescent when he got there. He turned the key in the lock to the security gate and drove into the Acapulco's parking lot. His own car, the one himself-at-forty had been driving, was still in its space.

"You thought I was kidding, did you, you bastard?" Justin's lips skinned back from his teeth in a savage smile. "I'll show you who was kidding, asshole."

Finding a parking space out on the street took another minute (a well-trained Southern Californian, he never thought to use one of the empty ones in the parking garage; those weren't *his*). Then he stormed up the steps into the lobby, opened the security door, and charged toward his apartment.

Click! One key in the dead bolt. *Clock!* The other in the lock. The door opened. Justin slammed it shut behind him. "All right, you fucker, now you're gonna get it," he growled.

No one answered. Justin strode into the bedroom. It was as empty of life—except his own—as the front room and kitchen had been. He checked the bathroom. He checked the closets. He checked under the bed. He didn't take long to decide he was the only one in the place.

But his older self hadn't taken his car. "He can't have gone far," Justin muttered: again, the Southern California assumption that nobody without wheels could do much. Justin scratched his head. Was himself-at-forty running for his life? Hopping a cab? Waiting for a bus? None of those made much sense.

But the chair in the bedroom was pulled a long way out from the desk. You couldn't use the iMac with the chair out there. You could sure as hell use a laptop, though. What would a laptop from 2018 be able to do? Justin didn't know, but the mere thought was plenty to make him salivate.

His older self had said coming back from then to now was a matter of good programming. If he had a machine like that, if he had the program on the hard drive, could he go back the way he'd come?

"How should I know?" Justin asked nobody in particular. But the apartment felt very, very empty. Maybe his older self had fled where he couldn't hope to follow for nineteen years.

Or could he? He knew some things he wouldn't have if his older self hadn't come back and . . . *And screwed up my life*, Justin thought. He knew going back in time involved superstrings and programming. The combination wouldn't have crossed his mind in a million years—no, in something close to nineteen years—if himself-at-forty hadn't returned to 1999 to meddle.

And he knew the thing could be done in the first place. Knowing that was half the battle, maybe more than half. He'd never let himself get discouraged. No matter how bleak things looked, he wouldn't give up and decide he was chasing something impossible.

And . . . A slow smile stole over his face. He had a nest egg now that he hadn't had before, thanks to the cash his older self had left behind. He hadn't blown very much of it. If he made some investments and they worked out, he could be sitting pretty by the time he got to the frontiers of middle age.

"Inflation," he said, reminding himself. "Gotta watch out for inflation."

Himself-at-forty had said his stash of cash wouldn't be worth nearly so much in 2018 as it was now. Whatever he put the money into, he'd have to make sure

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rising prices didn't erode it into chump change.

What he had to do right now was get his hands on the cash, which was still sitting back at the other apartment. Then he'd have to figure out how to put it into his bank account without getting busted as a drug runner or money launderer. You could put only so much cash in at a time, or else the bank had to report you to the Feds. He knew that. But what was the upper limit? He had no idea. *I'll find out on the Net*, he thought, and put it out of his mind for the time being.

As he drove over to the other apartment, something else struck him: *I can get rid of this car. That'll bring in some more money to help set me up.*

All that assumed his older self wasn't hanging around in 1999. Justin didn't *know* himself-at-forty wasn't, not for a fact. If his older self *did* remain here in the twentieth century, Justin still intended to punch his lights out the first chance he got.

He was loading twenties and fifties and hundreds into shopping bags, feeling a lot like a gangster, when he thought, *I can move out of this apartment, too, and get back whatever security deposits my older self paid—part of them, anyway.* In spite of the handfuls of greenbacks he was taking out of the drawer, every dollar felt important.

He wondered what his quarter from 2012 would be worth, and whether it would be worth anything at all. But then he shook his head. "I'll keep it," he declared, as if someone had told him not to. "It'll remind me what I'm shooting for."

More than a little nervously, he took the cash down to the car. He managed it without getting mugged. He didn't think he'd ever driven so carefully in his life as on the trip back to the Acapulco. He'd never watched the rear-view mirror so much, either. *Don't want to get rear-ended now. Oh, Jesus, no.*

As he parked in front of the apartment building, a nasty thought hit him. *What'll I do if he just walked away for a few minutes and now he's back in my place?* Punching his older self's lights out still seemed like a good plan.

But the apartment was empty. With a sigh of relief, Justin stashed the bags of cash in the little closet in the hallway that led from the living room back to the bedroom. Then he put a couple of pans by the door. He'd have to get the lock changed, but in the meantime at least he'd have some warning if his older self was still around and tried to come in.

"Have to get the rest of my stuff out of that other place, too," he said. But, for the time being, that could wait.

He quickly went through the apartment, looking for whatever his older self had left behind. Finding a laptop from 2018—if himself-at-forty had had one with him—would have been the grand prize. He didn't. But he did find a statement from a bank he wouldn't have patronized if a stagecoach had run over him. When he saw how much it was for, his eyes bugged out of his head: about as much as he had in those bags in the closet.

And it's mine, too, he thought dazedly. *If he's gone, it's mine. I can prove I'm Justin Kloster just as well as he could. I know my mother's maiden name just as well as he did.*

For a moment, thinking of only one thing at a time, he actually felt grateful toward his older self. A twenty-one-year-old guy with six figures' worth of money in the bank and with a plan to get ahead . . . What couldn't he do?

I can't have Megan. His joy blew out. Cash was great, but without his girl? Whatever his older self had done there, he'd screwed it up bigtime. And he'd said he'd never found anybody else who came close to her.

Maybe I can get her back, Justin thought. *Maybe in a couple weeks, or when school starts again and I see her. Or something.*

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He shoved the thought aside. He couldn't do anything about it now.

Himself-at-forty had seen to that. Justin started getting angry all over again.

And he didn't get any happier when he looked at what was in the refrigerator. It was all stuff he'd have to cook if he wanted to eat it: even worse stuff than had been in his older self's other place when he first got there. What were you supposed to do with ginger root or hoisin sauce? He didn't know, and he wasn't interested in learning. But then he started to laugh. He could afford to eat out, by God.

Eat out he did. Yang Chow was odds-on the best Chinese place in this end of the Valley. He devoured kung-pao chicken and chili shrimp, with a Tsingtao beer to put out the fire from the peppers. No sign of his older self when he got back.

Justin called the other place. The phone rang and rang. After it had gone on ringing for more than a minute, he hung up again, nodding. His older self wasn't there, either. The more he wasn't there, the more convinced Justin was that he'd gone back to 2018.

"He should have stayed there, the son of a bitch," Justin said. "Maybe Megan and me would have made it. Shit—even if we didn't, I'd still have the good memories he did. What have I got now? Not one damn thing."

Before he went to bed, he changed the sheets and bedspread. He didn't even want to think about what had happened on the ones he threw in the clothes basket.

He slept late the next morning, which annoyed him. He had a lot of stuff he wanted to do that day: formally leave the other apartment, close his older self's banking account and move the money to his own, sell that other Toyota and put the proceeds from the deal in the bank, too. He was just heading out the door when the phone rang.

"Jesus!" he said, and hurried back to the bedroom. Maybe it was his older self. That would screw things up. Or maybe it was Megan. That would do anything but. "Hello?"

It wasn't himself-at-forty. It wasn't Megan, either, dammit. It was his boss at CompUSA, and he sounded pissed to the max. "Where the hell are you, Kloster?" he shouted. "That graphic-design outfit is coming in this morning to order their new Macs, and they don't want to deal with anybody but you." He said something under his breath about "Macintosh primadonnas," then went back to bellowing: "What are you doing there when you're supposed to be here?"

Justin had forgotten all about his CompUSA job. Evidently, his older self had been holding it down pretty well. With all the money he had, he was tempted to tell his boss to stuff it, but he didn't. That would look bad on a résumé. He gave the best excuse he could think of: "I must have forgotten to set my alarm last night. I'll be right there."

His boss promptly tempted him to regret his choice, roaring, "If they show up before you do, you're toast!" and hanging up hard.

He did get there first, and had enough time to review things before the graphic designers trooped in. Before they trooped out again, they'd bought about fifty grand worth of computers and peripherals, and his boss was acting amazingly human. Said boss even took him to lunch at a Mexican place not nearly so good as Sierra's—though he wouldn't have wanted to go there now—and didn't say boo when he ordered a margarita to go with his enchilada and rice and refried beans.

After lunch, he was upgrading system software on one of the iMac demos when he heard footsteps behind him. He turned around to see who it was; the Macintosh ministore inside the CompUSA didn't get nearly the foot traffic he thought it deserved. "Lindsey!"

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he exclaimed. "What are you doing here?"

"Well, you told me where you worked." She looked nervous. "I just thought I'd come over and say hi. Hi!" She fluttered her fingers at him in an arch little wave, then quickly went on, "I don't want to make trouble or anything. I know you said you were seeing somebody." By the way she stood on the balls of her feet, she was poised to flee if Justin barked at her.

But that, right this second, was the last thing he wanted to do. "I was, yeah," he answered, and watched her eyes widen at the past tense, "but we just broke up. Somebody came between us, I guess you'd say."

"Oh, my God!" Lindsey exclaimed, and then frowned anxiously. "I hope you don't mean me. She wasn't, like, jealous 'cause you went up to Simi Valley and ran into me or anything? That'd be awful."

"No, no, no," Justin assured her. "Had nothing to do with you. It was another guy. An older guy." The first and last parts of that were true, anyway. The middle? He wasn't so sure.

"That's terrible!" Lindsey said. "You must be all torn up inside." She reached out and put a sympathetic hand on his arm.

"I was bummed," he admitted—about as much as a male his age was likely to say. "It's really nice, that you came all the way from Simi to see me." They both laughed, even though Justin hadn't quite made the joke on purpose. Lindsey smiled at him. He wasn't always fast on the uptake, but something got through. He set his hand on hers. "Who knows?" he said. "Maybe it won't work out too bad after all." ■

(EDITOR'S NOTE: For a complementary take on this story, see "Forty, Counting Down" in the current [December 1999] issue of Asimov's Science Fiction.*)*

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Dark Cities Underground, Lisa Goldstein, TOR, $22.95, 253 pp. (ISBN: 0-312-86828-6).

Shiva 3000, Jan Lars Jensen, Harcourt, Brace & Co., $24, 284 pp. (ISBN: 0-15-100454-4).

Starfire, Charles Sheffield, Bantam, $13.95, 401 pp. (ISBN: 0-553-37894-5).

The Far Shore of Time, Frederik Pohl, TOR, $23.95, 318 pp. (ISBN: 0-312-86618-6).

Ancients of Days: The Second Book of Confluence, Paul J. McAuley, Avon, $16, 386 pp. (ISBN: 0-380-97516-5).

The Icarus Hunt, Timothy Zahn, Bantam, $23.95, 363 pp. (ISBN: 0-553-10702-X).

Frontiers/Fronteiras, Maria Augusta and António de Macedo, eds., Simetria (Portuguese Science Fiction Association, Av. República, Pavilhão Dramático de Cascais, 2750 Cascais, Portugal, simetria@esoterica.pt), $14, 193 + 199 pp. (ISBN: 972-97495-1-5).

Refugees from an Imaginary Country, Darrell Schweitzer, W. Paul Ganley (P. O. Box 149, Amherst Branch, Buffalo, NY 14667-0149) & Owlswick Press (123 Crooked Lane, King of Prussia, PA 19406-2570), $15, 232 pp. (ISBN: 0-932445-65-9).

The Transparent Society, David Brin, Perseus, $15, 378 + vi pp. (ISBN: 0-7382-0144-8).

Greetings, Carbon-Based Bipeds! Collected Works: 1934-1998, Arthur C. Clarke, St. Martin's, $35, 549 + xvii pp. (ISBN: 0-312-19893-0).

As a species, we humans seem to have been fascinated by underground passageways for about as long as we have been recognizably human. Thirty thousand years ago—and more—we were crawling through European caverns so we could decorate the walls with vivid portraits of the game our lives depended on. We can only guess at the reasons, but some of those guesses suggest that the ancient cave painters were trying to control the supply of game, to bring back the migrating herds in the spring, or to ensure a fertile birth season.

The fascination continued through myths of underworlds for the dead to wander and King Minos's Labyrinth and Minotaur, through actual catacombs for refugee Christians and the bones of saints, and into the modern age, when every city is underlain by labyrinths of sewers (with myths of flushed-away alligators instead of Minotaurs) and subways.

And here is Lisa Goldstein's **Dark Cities Underground**, a charming tale of subways, children's stories, and a mythic quest for control. She begins by telling us that San Francisco's BART (Bay Area Rapid Transit) subway system is in the shape of an aleph, a sign of cabalistic import. On it, Barnaby Sattermole rides to a meeting with the Shadow Committee in a crypt in a Colma cemetery, where he reports on his efforts to find a certain entrance to the World Below, the Nether Land.

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That entrance had once been discovered by a boy, Jeremy Jones, who had made it past the dog-headed man who guarded the way, had adventures, and returned to tell his mother everything. She in turn had written a popular series of children's books about Jeremy's adventures in Neverwas. Now the Museum of Neverwas is opening, full of memorabilia, and Sattermole is hunting for the adult Jeremy, or Jerry.

So is Ruth Berry, who has a contract to write a book about mother, son, and Neverwas. Jerry is a recluse, thoroughly estranged from a mother who stole his tales, very unwilling to talk to writers or importunate Sattermoles. But soon Ruth and Jerry are allies and lovers, while Sattermole promises Sarah Kendall she can have her dismembered husband back from the dead and Ruth can regain her vanished daughter Gilly, if only they will find the door to the Land Below.

The quest is on, and the mysteries deepen. Jerry's father, it seems, was a subway engineer who worked on the London tubes as well as on BART. His predecessors were inspired in Egypt, where the yen for immortality has always been strong. There are hidden subway lines and abandoned stations everywhere, and if you take just the right turns you can enter BART in California and find yourself in London, Moscow, New York, anywhere there is a subway. And don't forget the Corn sisters, young, middle-aged, and ancient, who provide hints and clues from their dusty London apartment.

There are no links to ancient painted caverns or minotaurous mazes, but such are hardly necessary. Goldstein has done a marvelous job of melding modernity and myth, while also adding a bit of insight into the nature of children's tales.

It is hard to imagine just how much life has changed in the last thousand years. The tenth and eleventh centuries were a time when barbarians in oversized rowboats raided the cities of Europe. Men and children marched off by the thousands to liberate the Holy Land from its natives. Feudalism was alive and well. Democracy was a quaint practice of ancient Greece. Yet to be thought of were the printing press, sanitation, vaccines, electricity, internal combustion, and a zillion other things we take for granted.

What will life be like a thousand years from now? Some things will remain. For instance, the world's religions will remain recognizable though some practices are sure to change. Technology will change drastically. People will still love and hate, compete and obsess.

And perhaps Jan Lars Jensen will prove conservative in his estimate of an India where the Hindu gods roam the land in physical form. **Shiva 3000** tells us of Rakesh, who hears a Brahmin intoning *sim wi ta sicc'm, ep fel sim*. Soon appears on the horizon the god Jagganath (Juggernaut), built of wood and rolling forward on spiked wheels to demolish a city (please do note the "sic'em" in the chant that summons). He rescues a balloonist, finds shelter for them deep underground, and follows a group of Kama Sutrans back to the surface. In due time, he learns that he has rescued Vasant, the Royal Engineer, who hates, fears, and distrusts the Kama Sutrans, for they have infiltrated the royal palace in Delhi. He reveals his own story—the Baboon Warrior, slayer of rampaging gods, defeater of armies, raper of princesses, despoiled his own bride to be. Sitting glumly on the seashore, he was visited by Shiva and given the task of slaying the Baboon Warrior. Oddly, if he deviates from his aim, he is racked by pain. He calls it dharma; others might say mission, destiny, geas.

Vasant doesn't much want to make a team with Rakesh, but Rakesh insists. Together they encounter a war fought with blowers and bags of red pepper and turmeric (ouch!). They find a hollowed mountain inhabited by Pragmatics who look for the truth in the world

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and have learned that many people have special organs (chakras).

Together Rakesh and the Pragmatics invade Jagannath and find that it runs on engines and is maintained by slaves culled from the cities it has flattened. The slaves are commanded to their tasks by the divine will; the Pragmatics find that they can resist that will by mental exercises and copper helmets.

The modern reader recognizes technology, not gods, and wonders what it was that brought this pattern into being. Why were gods constructed and loosed? Why was a populous nation so subordinated to mechanical masters? Jensen hints that one of the gods' goals is population control, that they are the only way to rein in human reproductive folly and achieve homeostasis.

The astute reader might wonder whether the gods are themselves controlled and kept from excess, and here of course is the crux of the tale. I'll say no more, for it is enough to praise Jensen for drawing a portrait of a strange and wonderful future India and giving us a drama of human obsession and divine conflict firmly in the classic tradition.

Indeed, some college lit major looking for a topic for a senior thesis might have a great deal of fun comparing this to Homer's *Odyssey*.

Recommended.

Did you enjoy Charles Sheffield's *Aftermath* (reviewed here in November 1998)? For it, he blew up Alpha Centauri, blasting Earth with a wave of climate-altering heat and civilization with a circuit-frying EMP, thus giving his cast of characters a thoroughly challenging stage upon which to strut their parts. It was the End of the World, complete with religious and political nuts eager to finish off whatever survived in the name of glory and/or salvation.

Or it would have been if not for some of those characters, such as astronaut Celine Tanaka and ace physicist Wilmer Oldfield, just back from Mars, cloning nerd Oliver Guest, serving a six-hundred-year sentence in suspended animation for murdering beautiful and intelligent disadvantaged teen-aged girls, and others who just would not let civilization die. And then Wilmer's Einsteinian mind had to toss in the kicker: Fifty years hence, the charged-particle front would arrive. The *real* End of the World, unless a screen can be erected in space to deflect it.

The sequel—**Starfire**—was inevitable. Oliver Guest is still free, though he keeps a low profile in a refurbished Irish castle, where he lives with his darlings (he didn't kill those girls because he was a fiend—he had saved their genomes in a turtle's cells, and when he had the chance, he brought them back to life; his motive all along was to give them the chance they should have had). One of his *Aftermath* colleagues is on the doorstep, recruiting him to help hunt down another murderer of young girls, this time on Sky City, the space station from which Earth's particle shield is being constructed. It will turn out to be a horribly traditional murderer and motive that contrasts with Guest's own crime and—perhaps—helps to redeem him.

Meanwhile, Celine—now President—has Wilmer on her own doorstep, with word of a new threat: A deadly component of the particle blast is going to arrive ahead of schedule, and the shield will have to be drastically redesigned to meet it. The project is already behind schedule—thanks to subversion of its efforts by greedy private interests—and they have only a month instead of years, but if they can't manage it, the Earth is fried.

Whoopee! There are more surprises in store too, but that should be enough to make you rush out and buy the book. You'll enjoy it, for Sheffield as usual tells a rousing good story with plenty of hard science content for his fans. Yet there's more, too. This book and its predecessor may be much more valuable for their

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subtext. Sheffield is here deeply concerned with the ethical question of whether the ends can ever justify the means. To explore it, he contrasts the noble-motived Guest with the vastly more self-serving Eye of Argos, Gordy Rolfe, Nick Lopez, and Sky City's unknown murderer. Some ends are more worthy than others, he says, and perhaps even wicked means can be accepted in their pursuit.

The Far Shore of Time concludes Frederik Pohl's "Eschaton Sequence," following *The Other End of Time* (reviewed here in March 1997) and *The Siege of Eternity* (April 1998). The series began when aliens announced that humanity was about to be taken over by the "Beloved Leaders" and secret agent Dan Dannerman and astronomer Pat Adcock, among others, were snatched and shipped through a matter transmitter for study. Soon it was clear that the aliens were already among us and that many people carried in their brains bugs that transmitted every thought and sense to the aliens. Worse yet, the "Beloved Leaders" want to turn us into slaves and puppets, all to protect us from their foes, the evil scuzzball Horch.

Since a matter transmitter must turn one into a stream of information, it is of course child's play to record the stream and play it back to make new copies of whatever is transmitted. Dan has serious problems when he learns that copies of him and Pat have been vivisected and otherwise mistreated. He also has trouble when he realizes that the Pat he loves is married to another him. But before he reaches that point, he—or the one of him still on the prison planet liberated by the Horch—must get acquainted with the aliens, learn that there is a major war on, spot some potentially useful technology, and persuade the Horch to send him home to save the Earth.

Dan often seems peculiarly dense and slow-witted (I would expect a secret agent to be more adaptable). That gives Pohl plenty of time to make clear to the reader exactly what is going on, but it doesn't endear the series to me. It's adequate, and the second and third members of the series exceed the first, but wait for the paperbacks.

Paul J. McAuley's **Ancients of Days** is the second entry in his "Confluence" series, set on a long needle of rock with a river running half its length, mountains to one side, the edge of the world to the other, surrounded by a vast bubble of air in which float living islands. This world was created ages ago by the Preservers, who also peopled it with a host of animals gengineered into human form and sentience. Each "bloodline" has its distinguishing features and talents but all are people; the one important difference is whether a line has "changed"—awakened to full self-consciousness. The "unchanged" live their lives largely on autopilot, and if they seem little different from ourselves, perhaps that is McAuley's comment on us.

The series' first volume, *Child of the River* (reviewed here in November 1998), introduced Yamamanama, found as a babe floating on the River, in form of no known bloodline, possessed of strange talents (he can make machines do his bidding), pursued by functionaries of the malign Department of Indigenous Affairs. He left home to seek information about his bloodline, his heritage, his identity, and his destiny, and discovered a political maelstrom in a Palace that makes Gormenghast look like a child's playroom toy. Now he is in the thick of it, falling in and out of captivity, gaining allies, losing friends, and being led down the River to a land of ruins where his kin once dwelt. But there is a war in the way, the Department is still after him, and in his late stepfather's papers, Yama finds a clue that his own birth was linked to changes that threaten the continued existence of the world.

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Yama is a bewildered innocent, interesting and congenial, with no end of adventures ahead. His friends and sidekicks are less interesting; McAuley invests less energy in them, for in the way of such adventures, he must periodically scrub the stage clean except for the hero and the chief villain. But one reads on with pleasure, eager for new revelations about the history of Confluence and Yama's role in its Last Days.

And McAuley continues to remind—pleasurably—of Gene Wolfe.

Timothy Zahn's **The Icarus Hunt** is a fast-moving adventure bound to earn him a bundle of boodle on two counts. With the new *Star Wars* movie now out, and with "The #1 *New York Times* best-selling author of the original blockbuster *Star Wars* trilogy" blazoned across the cover, how can he lose? Nor will fans of his other work be disappointed.

The tale opens in the traditional spaceport bar, where Jordan McKell, billed as a struggling star-freighter pilot who got so deeply in debt that his only recourse was to enlist with the worst of evil interstellar crimelords, is being asked to pilot a ship with a sealed cargo to Earth. The hints are immediate: Interstellar trade is monopolized by the Patth, who have the fastest stardrive around and use their clout to beat down both competitors and objections. And immense commotion has just erupted around an archeological site just over the horizon.

My immediate suspicion was that someone had just dug up an ancient super-stardrive. The Patth think so too, and almost as soon as McKell and his pick-up crew—which includes the obligatory saboteur and murderer—take off, the hunt is on. Run and dodge, feint and run again, from world to world, while the Patth get closer and closer until the reader all too easily imagines them chortling evilly and twisting their waxed mustachios (which they don't have—I'm kidding) in anticipation of victory.

Many things, of course, are not what they seem, but all ends well and the reader feels well and truly entertained. Zahn has the right touch for this kind of tale.

Do you teach Portuguese? Do you teach English to Portuguese speakers? Do you teach world literature? Do you have an interest in foreign SF? If you can say "Yes" to one or more of those questions, you will find the Portuguese Science Fiction Association's (Simetria) **Frontiers/Fronteiras** interesting. It's their third SF anthology, and though it draws upon the larger SF world with a couple of stories by Stephen Baxter and Gwyneth Jones, it offers an interesting sample of eight dishes from a cuisine with very different flavors, much heavier on irony and surrealism than we usually see here. Two of the eight chefs are the Brazilian writers Gerson Lodi-Ribeiro and Roberto de Sousa Causo. The Portuguese contributors are Daniel Tércio, Maria de Menezes, António de Macedo, João Tiago, João Barreiros, and David Alan Prescott (actually a Brit living in Lisbon). There is also an essay on Portuguese SF by Teresa Sousa de Almeida.

I asked you about teaching languages because the book is a pony. Open one side, and the text is in Portuguese. Turn it over, and you have the English translation (which admittedly sounds a bit off; the translator did not perform the kind of polish that removes all traces of original word order and pattern). The point of the anthology, writes Simetria's Luis Filipe Silva, is "to present the Portuguese audience with the modern trends in SF [and] for the Portuguese writers to get themselves known (mainly in Portugal . . . since our anthology is the only place where one can find original Portuguese work at short story length in SF)." But it can also serve the other purposes I mentioned.

In **Refugees from an Imaginary Country**, Darrell Schweitzer collects

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nineteen very entertaining fantasies. Some are dark, some are jolly, all are deft and often witty. For instance, I quite enjoyed "The last dangerous lunacy," in which Tom O'Bedlam and his ex-keeper flee Death, encounter a pirate with a tendency to say "Argh," and remember an old joke about a centipede.

It is the wit that makes Schweitzer's work stand out. I commend it to you.

David Brin, space physicist and science fiction writer of considerable note, is also a contrarian philosopher. We saw a bit of that in the essays he reprinted in *Otherness* (reviewed here in January 1995), where his theme was the peculiar openness to alternatives that marks America and (of course) SF. In **The Transparent Society**, he takes some of his ideas much further. The debates he enters are those over privacy, anonymity, encryption, and freedom of speech that swirl around the broad topic of the Internet today. Brin notes that the basic argument is over whether flows of information should be restricted, points out that freedom-loving netizens tend to like the idea of restricting government's access to information (they like encryption and hate the idea that government could have access to their code keys) while government wants to restrict *access*, and reminds us that what has made American democracy, prosperity, and freedom work has been precisely broad access to information of all sorts, and therefore an unprecedented level of accountability for the powerful.

Perhaps, he says, we should take that lesson to heart and open the information floodgates. There may be times when it is appropriate to keep things to yourself, but in general doing without codes and the like might work very well. Knowing that we were being watched—or that we *might* be—could prompt us to moderate some of our more egregious behaviors. And if the system were so arranged that we could look back, that could moderate extreme nosiness.

Would "transparency" work? Brin considers the ramifications of living in the light instead of the dark at some length, and he convinces me that we're halfway there already and that the benefits are worth striving for. He may not convince you, but I am sure you will find him interesting, thoughtful, and thought-provoking. (I am also sure my students will, when I force them to read it.)

Greetings, Carbon-Based Bipeds! is *not* the collected works of Arthur C. Clarke. That would require much more than a single book, even one as large as this one. It's not even the collected nonfiction. It is rather a selection of representative nonfiction pieces, arranged by decade to provide a sort of travelogue through the career of one of science fiction's premier contributors. There are the wartime radar work, the comsat idea, the undersea explorations, discovering Sri Lanka, and a great deal more, expressed in articles, essays, reviews, and speeches.

Buy it to honor a great man, but also as a record of a period when history itself was in transition. Clarke has witnessed and contributed to our dawning awareness of outer space and under sea, satellites and computers, and this book articulates the dreams of millions. ■

A generation which ignores history has no past—and no future.

— Robert A. Heinlein

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BRASS TACKS

Dear Stanley,

I heartily concur with the larger lesson to be learned from the Y2K problem, which you pointed out in your June editorial. However, I disagree with your explanation of why it came about. Rather than saving money, I believe there were other reasons behind the bug, which also bear examination.

The Y2K Bug was not born ten years ago when you were wisely setting up your databases to avoid it. It's much older. It started when computers filled rooms, cost gazillions, and were only owned by governments, universities, and major corporations. The person writing the code (on punch tape, perhaps) did not have the option of saying, "Hey, guys, let's splurge on a little more memory here." He did not have access to the purse strings. He was shown to the computer room and told, "This is the latest, greatest machine we just bought. And to justify the huge expense, we need it to do this, and this, and this. Oh, and this, and this, and that, too." So he was trying to use every one of the computer's limited brain cells as hard as he could.

Lesson #1: The person who actually understands the device and has to work with it should have some voice in its design and features.

Then the mistake was propagated because it was The Way It's Done. This is also known as The Industry Standard.

Lesson #2: Just because it's always been done that way doesn't necessarily mean it's the best way to do it.

Finally, even people who recognized the future problem felt certain that the hardware and software they were currently using would have been long ago replaced by the year 2000. Nobody expected the same old creaky systems to get added onto and patched and spliced together the way they did. They got to be so complex, with so many layers to them, that no one fully understands them anymore, and trying to excise the obsolete material buried at the core could easily kill the patient.

Lesson #3: The system is only as good as its weakest link. Design so you can move your data to new systems as necessary, and leave the old ones behind, instead of trying to graft strong fast new limbs onto an elderly, failing torso. And design new systems to easily accept data from older ones.

Just my two cents worth.

Oh, and while we're on the subject of the millennium, I have the final answer to when it should be celebrated, which should please everyone. Something like this is too big to only celebrate for 24 hours. So let's celebrate the turn of the millennium for a full year, starting at midnight, December 31, 1999, until midnight, December 31, 2000.

SHARI PRANGE
Bonny Doon, CA

Sir:

Yes!!! Lots of us knew about the inevitability of the year 2000. Alas and alack, we were prophets crying in the wilderness. . . .

Seriously: I, as a data processing (*not* "computer science") professional with approximately thirty-five years of experience, none of them twice, I must put

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the blame for the "Y2K" debacle squarely on the shoulders of . . . management.

There are two primary causes, or, rather, two sides to the coin, for each is but a reflection of a far bigger problem.

Cause One: "*Not On My Shift*. I'm here until I can get a better job: I look good by bringing in projects under time and under budget. Get the job done; if there is a problem we'll fix it later. . . . (Unspoken: on someone *else's* shift . . . not mine.)"

This, of course, is just a variant of "Put your Company hat on".

Cause Two: "These people (meaning the programmers and systems analysts being "managed") talk funny, and don't get along with me: I don't like them. I don't *understand* them. I'm going to promote this guy who is NICE to me, that I can talk to; *not* those weirdos. He draws such nice charts and doesn't spend all his time with his nose in a book. . . ."

This of course, is simply an instance of the general demise of management-by-doers and its replacement with management-by-lawyers, management-by-accountants, management-by-sons-in-law, etc.

The above two scenarios are *not* exaggerations. They are quite common. The truly frightening thing is how often they occur, even in companies whose whole existence depends on computers and communications.

I was on a project at a major bank in New York. One which had been put together out of three (count em: three) huge banks. *Nothing* was Y2K ready (as of October 1998). The systems the bank was running was the result of "one from column A, one from column B . . ." picking and choosing among the systems of the precedent banks: No two systems worked together, and not one was Y2K ready. . . . The project I was on, which handled $100 million *per day* was run by a "very nice man," who had been with the bank for twenty years, had eight quarter-century men (me included) reporting to him, and yet he listened to a control clerk who had been on the job for three years and had *never* written a program in his life.

My message is: Y2K? I've been ready since 1970. So have most of my professional acquaintances.

The Plains Indians didn't have much choice. Much of where they lived was too arid to support farming, and they did not have domesticated draft animals, or the metallurgy to support sod-busting. Tall-grass prairie does not lend itself to scratching with a stick to plant crops. Pronghorn antelope are damned difficult to hunt, even with a 270 Winchester and an 8x scope. Digging for prairie dogs doesn't cut it, either. As I said: they didn't have much choice.

American management, indeed, society, seems to have made a deliberate, conscious decision that "brains are nerdy" and "planning past the end of next quarter is the mark of a propellerhead."

Draw your own conclusions. Heinlein was right: the "Crazy Years" are coming.

ED OLEEN

Dear Stanley,

Thanks for your editorial in the June 1999 issue. You make an excellent argument for flexibility. Just for the record, however, I should point out that the parallel between the Plains tribes and late-twentieth-century America may be even closer than you indicate. The Indians' total dependence on the buffalo was in fact a relatively recent phenomenon, made possible by the arrival of the horse on the plains, which allowed them to exploit the resources of the region much more completely.

Two or three hundred years earlier, tribes such a as the Arikara and the Pawnee had permanent villages at the edge of the High Plains, surrounded by cornfields, from which they trekked out to the plains on foot twice a year to hunt buffalo. Other tribes were recent arrivals to the area, pushed westward by the pressure (and the guns) of European set-

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tlement. For instance, our first record of that quintessential Plains tribe, the Lakota, is a treaty made between them and William Penn in western Pennsylvania.

Thus the story of the Plains buffalo culture is not one of a people unable to adapt from an ancient and entrenched way of life, but of peoples who within the space of a generation or so, abandoned a diverse lifestyle, with corresponding changes in technology, social institutions and religion. No doubt they too had grandmothers who could remember planting corn, as I remember learning to use a manual typewriter. Given time, no doubt they could have adapted once more, but what strength they had left was destroyed by smallpox-infected blankets and superior firepower.

Having a variety of sources for food, or communication, transportation, and data storage, provides the redundancy necessary for the survival of any living system. It also helps if you can all work together to "watch the basket!"

DIANA L. PAXSON

Dear Stan:

Your editorial on "The Bug and the Buffalo" was, as usual, well thought out. But I'd like to take issue with your conclusion that "Unless they [managers responsible for software] were quite sure there would be no possible use for them [records with date information] beyond 12/31/99, everything should have been formatted to allow trouble-free use beyond that date "regardless of the cost."

Statements with extreme qualifiers such as "no possible use" and "regardless of the cost" are trouble, both generally and in this particular case. What your statement implies is that the managers should have been willing to incur an arbitrarily large cost for the sake of an arbitrarily small probability. Business decisions can't be made this way.

The difference between the computers of today and those of ten, twenty, and thirty years ago isn't just a matter of speed and capacity. The increase in these two quantities has resulted in a more pervasive difference: the complexity of the programs which computers can run. Today word processors play movies, show annoying help windows with dancing computers, and have scripting languages powerful enough to be attacked by viruses. In 1979, that would have been a fantasy too wild for any SF magazine.

The further back in time we look, the more programming had to be focused on the immediate problem. Variable-length data fields often weren't practical, especially with punched-card data entry; two additional digits for a date could mean two letters taken from a name or address field, causing a risk of more immediate problems. Conditional programming to handle both two and four-digit years would have been an extravagance.

Counterintuitive as it seems, postponing the solution may actually have been the most cost-effective approach, in both the short and the long run. Fixing things today is made more difficult by the loss of source code and the existence of entrenched databases; on the other hand, the computer resources to solve the problem are greater and the costs of those resources are smaller by orders of magnitude.

This isn't to deny that a great many "Y2K" problems are the result of extreme short-sightedness; but applying the tradeoffs of today to the very different costs of the past is a mistake.

GARY MCGATH

Dear Brass Tacks:

I'm sure that this will come as something of a shock to Mr. Kooistra, but as a matter of fact you can create a "perfectly" flat surface without any tools, essentially by "cracking rocks together." The first precision machine tools, after all, were not delivered to us by ancient astronauts; they were built by men who had no precision tools to start with.

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The procedure is quite simple, actually: Take three rocks, and chip them roughly flat. Rub A against B, occasionally rotating 90°, until all the high points had been worn down. Repeat the procedure with B against C, then C against A, continuing the rotation, until the desired level of flatness is achieved. Nothing but patience stands between you and flatness to within millionths of an inch! (Use only two stones, and you will generate complementary spherical surfaces; Telescope mirrors, in fact! The third stone constrains the radii to be infinite, as that's the only way three surfaces can be complementary.) Similar procedures exist for achieving "perfect" perpendicularity. In fact, this is essentially how high-precision surface plates are manufactured even today. (Or finished, rather; "High precision" machine tools are used to rough them out, and then ultra-high levels of flatness are achieved by rubbing them together!)

While this procedure was developed during the 1800s, using advanced geometric reasoning, Euclid could have understood how it works, and it could easily have been stumbled across by any ancient stone mason. Using handmade reference blocks, a mason could indeed manufacture a box from a single piece of granite with flat and square interior walls. This isn't hardly to say, of course, that ancient Egyptians didn't have a fairly high level of technology. Merely that ultra-flat stone work is no proof of that level of technology.

BRETT P. BELLMORE

The author replies:

No, nothing in your letter came as any kind of shock to me. You both managed to read too much into some of my comments, while at the same time not reading other comments closely enough.

I have some doubts about the applicability of the three-stone technique you (and others in other letters) have cited as a means to producing the specific artifacts in question as described in the Dunn book, but I would be delighted to have those doubts dispelled.

However, you have a problem in your last paragraph, though not with me. If you think you can convince any mainstream Egyptologists that a technique first developed in the 1800s was employed by the ancient Egyptians 4,500 years earlier, then you are welcome to try to convince them of that. My guess is that they'd just ignore your letters or look at you funny if you showed up at their universities with blocks in hand.

JEFFERY D. KOOISTRA

Dear Stanley,

I greatly appreciated Jeffery D. Kooistra's article, "The Giza Power Plant," published in the June. Quite a lot has happened since the original article "Advanced Machining in Ancient Egypt" appeared in the August 1984 issue, and I thought I would take this opportunity to update my *Analog* family while at the same time responding to Mr. Bellmore's letter (and also a very intelligent and insightful letter from Brian Melody to Jeff which Jeff also forwarded to me).

Jeff did a great job with the article, though in the short space he had to cover a book that was twenty-one years in the making, he couldn't possibly have covered every single detail of the artifacts I describe in it. The reality is that after three trips to Egypt, I find myself each time wishing I had more specialized equipment to do a better job of recording the metrology of the stones.

Nevertheless, after just returning from a trip to Egypt, where I was able to broaden the scope of my inspection of the artifacts, I can respond to Mr. Bellmore and Mr. Melody with confidence that the questions they raise will be answered.

These writers raised a very good point in their letters when they described a method of finishing flat surfaces using three plates to lap and cross-reference accuracy. They are correct when they say that machine beds and

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surface plates used to be, and in some cases still are, finished in this manner. I have performed this work on machine beds. It is painstaking and tedious work, but there is a good reason to do it. Without this kind of precision, the machine would not perform to standard.

And this is where Mr. Melody raises another good point—and one that I believe has even greater implications. Why do it if it is not necessary?

In my most recent trip to Egypt I took along a 12-inch long parallel that was ground flat to within .0001 inch. I also took a precision solid square and a set of Starret radius gauges tools that I didn't have with me on my previous trips. My intention was to go back to the rock tunnels at the temple of the Serapeum and further inspect the huge 65-ton granite and basalt boxes that I describe in my book, which, to me, displayed the most startling evidence of precision machine tooling. Unfortunately, the site was closed and, try as I might, no amount of baksheesh would get me in there. I had to be content with going back into Khafre's pyramid, the second largest pyramid on the Giza Plateau, and inspecting the inside of the granite box that is housed in the bedrock chamber.

I was not disappointed. Surrounded by a group of conference attendees, I jumped down into the box and placed the parallel against the surface of the granite. Sliding the parallel along the surface with a flashlight behind it the video cameras caught on film the details of the granite. This visit brought me new insights as to the details of this piece that preclude the three-plate method of lapping.

Using a three-plate lapping method, the end product is a smooth, polished surface as the high-spots are worked out. Yet the box did not display these characteristics. The surface was indeed precise, with respect to flatness, but it was not completely worked down to a fine smooth surface. It was mottled with very fine depressions, as though components of the granite, either quartz or mica, had broken or been pulled away from the feldspar substrate. This *is* significant! Having worked with granite surface plates, that are lapped to such accuracy, the act of lapping does not pull the quartz away from the substrate. All the components of the granite reach the same plane and the same degree of polish.

Then my attention turned to the corners. As anyone who has done the work knows, finishing the inside of a box—or cavity—is exponentially more difficult than finishing the outside. This is why Mr. Melody astutely recognized in his letter that to accomplish this degree of precision using a three-plate method it would be better if the box was open on both ends and the plates could pass completely through. But the box is closed at the bottom! Not only that, the four inside corners that I inspected with my solid square were—guess what?—Square! The southwest corner had a slight inaccuracy where the edge of the steel square did not completely touch over the length of it, by a few thousands of an inch, but I was unable to detect any variation in the other three corners.

This is difficult work! But let's ramp the difficulty up a little higher! Let's see what the corner radius is. Understanding that the smaller the radius the more difficult and painstaking the effort.

Is it a half-inch radius? No! A quarter-inch radius? No! I had to pull several gages out of my set before finally placing a 3/32-inch radius gauge in the corner and finding a fit! This was in the corner radii of the sides of the box. The radius at the bottom of the box was 7/16-inch. Now come-on folks! Dolerite balls? Copper chisels? Give me a huge break! Don't take my word for it, get the experience under your belt by first doing the work, then gather the tools and go to Egypt. The only question remaining in my mind is what were these incredible artifacts used for?

CHRISTOPHER DUNN

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UPCOMING EVENTS Anthony Lewis

19–21 November 1999
TROPICON 18 (South Florida SF convention) at Clarion Hotel, Hollywood, FL. Guest of Honor—Mike Resnick. Registration—$24 until 18 October, $28 at the door. Info—South Florida Science Fiction Society, P.O. Box 70143, Fort Lauderdale, FL 33309. Phone—(954) 739-4376. Email—tropicon@scifi.squawk.com; URL—http://scifi.squawk.com/tropicon.html

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26–28 November 1999
LOSCON 26 (Los Angeles SF conference) at Burbank, CA. Guest of Honor—Connie Willis; Artist Guest of Honor—Alex Ross; Fan Guest of Honor—Joe Siclari. Registration—$35 until 31 October, $40 at the door. Info—LosCon 26, c/o LASFS, 11513 Burbank Blvd., North Hollywood, CA 91601. Email—loscon26@lasfs.org; URL—www.lasfs.org/loscon26

26–28 November 1999
CONCAT '99 (Tennessee SF conference) at Knoxville, TN. Guest of Honor—Neil Gaiman; Artist Guest of Honor—Lisa Snelling. Registration—$25 until 10 November, $35 at the door. Registration limited to 500. Info—ConCat 11, Box 1563, Knoxville, TN 37901-1563. Phone—(423)523-3193. URL—www.vic.com/~chloiea/ConCat

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26–28 November 1999
CHAMBANCON 29 (downstate Illinois SF conference) at Champaign, IL. Guest of Honor—Andrew J. Offutt; Fan Guests of Honor—Samanda B. Jeude and Donald Cook; TM—Wilson "Bob" Tucker. Registration—$25 in advance, $30 at the door. Info—ChamBanaCon 29, Box 2908, Springfield, IL 62708 (you must enclose a SASE). Phone—(217)753-8934. Email—ChamBanaCn@aol.com

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10–12 December 1999
SMOFCON 17 (SF convention runners conference) at New Orleans DoubleTree Hotel, New Orleans LA. Registration—$60 until 30 November, $70 at the door. Info—Smofcon 17, Box 61363, Sunnyvale, CA 94088.

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31 August–4 September 2000
CHICON 2000 (58th World Science Fiction Convention) at Hyatt Regency, Chicago, IL. Guests of Honor—Ben Bova (former editor of *Analog*), Bob Eggleton, Jim Baen, Bob & Ann Passovoy; TM—Harry Turtledove. Registration—$150; supporting $40. [These are the latest posted rates as of the time this column went to press.] This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Info—Chicon 2000, Box 642057, Chicago, IL 60664. Email—info@chicon.org; URL—www.chicon.org

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Convention runners—If your convention has a telephone, FAX, email, or Web page URL, please let us know so that we can publish this information.

Convention attendees—When calling conventions for information—do not call collect and do not call too late in the evening. It is best to include a SASE when requesting information; include an IRC if the convention is in a different country. □

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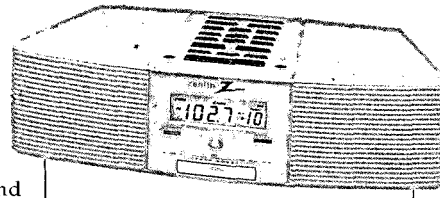

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